EMERSON.
Industrial Automation

User Guide

SM-EtherCAT

Unidrive SP
Affinity
Digitax ST
Commander SK
Mentor MP

Part Number: 0471-0128-02
Issue: 2

CONTROL
TECHNIQUES

www.controltechniques.com

General Information

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or adjustment of the optional parameters of the equipment or from mismatching the variable speed drive with the motor.

The contents of this guide are believed to be correct at the time of printing. In the interests of commitment to a policy of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance, or the content of the guide without notice.

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Environmental Statement

Control Techniques is committed to minimising the environmental impacts of its manufacturing operations and of its products throughout their life cycle. To this end, we operate an Environmental Management System (EMS) which is certified to the International Standard ISO 14001. Further information on the EMS, our Environment Policy and other relevant information is available on request, or can be found at www.greendrives.com.

The electronic variable speed drives manufactured by Control Techniques have the potential to save energy and (through increased machine/process efficiency) reduce raw material consumption and scrap throughout their long working lifetime. In typical applications, these positive environmental effects far outweigh the negative impacts of product manufacture and end-of-life disposal.

Nevertheless, when the products eventually reach the end of their useful life, they must not be discarded but should instead be recycled by a specialist recycler of electronic equipment. Recyclers will find the products easy to dismantle into their major component parts for efficient recycling. Many parts snap together and can be separated without the use of tools, whilst other parts are secured with conventional fasteners. Virtually all parts of the product are suitable for recycling.

Product packaging is of good quality and can be re-used. Large products are packed in wooden crates, while smaller products come in strong cardboard cartons which themselves have a high-recycled fibre content. If not re-used, these containers can be recycled. Polythene, used on the protective film and bags from wrapping product, can be recycled in the same way. Control Techniques' packaging strategy favours easily recyclable materials of low environmental impact, and regular reviews identify opportunities for improvement.

When preparing to recycle or dispose of any product or packaging, please observe local legislation and best practice.

Software Statement

This Solutions Module (SM) is supplied with the latest software version. When retro-fitting to an existing system, all software versions should be verified to confirm the same functionality as Solutions Modules of the same type already present. This also applies to products returned from a Control Techniques Service Centre or Repair Centre. If there is any doubt please contact the supplier of product.

The software version of the Solutions Module can be identified by looking at Pr **MM.02** and Pr **MM.51**, where **MM** is the relevant menu number for the Solutions Module slot being used.

See Pr **MM.02** and Pr **MM.51** description later in this manual for more information.

The software version takes the form of xx.yy.zz, where Pr **MM.02** displays xx.yy and Pr **MM.51** displays zz (e.g. for software version 01.01.00 Pr **15.02** will display 1.01 and Pr **15.51** will display 0).

REACH legislation

EC Regulation 1907/2006 on the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) requires the supplier of an article to inform the recipient if it contains more than a specified proportion of any substance which is considered by the European Chemicals Agency (ECHA) to be a Substance of Very High Concern (SVHC) and is therefore listed by them as a candidate for compulsory authorisation.

For current information on how this requirement applies in relation to specific Control Techniques products, please approach your usual contact in the first instance. Control Techniques position statement can be viewed at:

http://www.controltechniques.com/REACH

Contents

1 Safety Information

1.1 Warnings, cautions and notes

1.2 Electrical safety - general warning

The voltages used in the drive can cause severe electrical shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the drive.

Specific warnings are given at the relevant places in this user guide.

1.3 System design and safety of personnel

The drive is intended as a component for professional incorporation into complete equipment or a system. If installed incorrectly, the drive may present a safety hazard.

The drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control equipment which can cause injury.

Close attention is required to the electrical installation and the system design to avoid hazards, either in normal operation or in the event of equipment malfunction. System design, installation, commissioning / start up and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this user guide carefully.

The STOP and SECURE DISABLE / SAFE TORQUE OFF functions of the drive do not isolate dangerous voltages from the output of the drive or from any external option unit. The supply must be disconnected by an approved electrical isolation device before gaining access to the electrical connections.

With the sole exception of the SECURE DISABLE / SAFE TORQUE OFF function, none of the drive functions must be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.

The SECURE DISABLE / SAFE TORQUE OFF function is only available as standard on the Unidrive SP / Digitax ST. The Affinity, Commander SK and Mentor MP drives do not have such a feature.

The SECURE DISABLE function on Unidrive SP and the SAFE TORQUE OFF function of the Digitax ST meet the requirements of EN954-1 category 3 for the prevention of unexpected starting of the drive. They may be used in a safety-related application. **The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards.**

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Careful consideration must be given to the functions of the drive which might result in a hazard, either through their intended behavior or through incorrect operation due to a fault. In any application where a malfunction of the drive or its control system could lead to or allow damage, loss or injury, a risk analysis must be carried out, and where necessary, further measures taken to reduce the risk - for example, an over-speed protection device in case of failure of the speed control, or a fail-safe mechanical brake in case of loss of motor braking.

1.4 Environmental limits

Instructions in the *Unidrive SP User Guide*, *Mentor MP User Guide*, *Affinity User Guide, Commander SK Getting Started Guide*, *Commander SK Technical Data Guide*, *Digitax ST Getting Started Guide* and *Digitax ST Technical Data Guide* regarding transport, storage, installation and use of the drive must be complied with, including the specified environmental limits. Drives must not be subjected to excessive physical force.

1.5 Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the cross-sectional areas of conductors, the selection of fuses or other protection, and protective ground connections.

The *Unidrive SP User Guide, Mentor MP User Guide*, *Affinity User Guide*, *Commander SK Technical Data Guide* and *Digitax ST Technical Data Guide* contain instructions for achieving compliance with specific EMC standards.

Within the European Union, all machinery in which this product is used must comply with all relevant safety and EMC directives applicable to the installation.

1.6 Motor

Ensure the motor is installed in accordance with the manufacturer's recommendations. Ensure the motor shaft is not exposed.

Standard squirrel cage induction motors are designed for single speed operation. If it is intended to use the capability of the drive to run a motor at speeds above its designed maximum, it is strongly recommended that the manufacturer is consulted first.

Low speeds may cause the motor to overheat because the cooling fan becomes less effective. The motor should be installed with a protection thermistor. If necessary, an electric forced vent fan should be used.

The values of the motor parameters set in the drive affect the protection of the motor. The default values in the drive should not be relied upon.

It is essential that the correct value is entered in the motor rated current parameter, Pr **5.07** (or Pr **0.46** in Unidrive SP, Mentor MP, Affinity and Digitax ST, or Pr **0.06** in Commander SK). This affects the thermal protection of the motor.

1.7 Adjusting parameters

Some parameters and/or objects have a profound effect on the operation of the drive. They must not be altered without careful consideration of the impact on the controlled system. Measures must be taken to prevent unwanted changes due to error or tampering especially if a remote user can access the drive parameters.

1.8 General safety considerations for remote operation

SM-EtherCAT enables the possibility of remotely controlling a machine from a distance. It is vital that when connecting to a machine remotely, adequate safety procedures are implemented to prevent damage to the machine or injury to personnel.

Any connection to a live system has the possibility of altering the state of the machine, adequate procedures must be implemented to cover this situation.

It is the responsibility of the machine builder to ensure that such a system is safe and complies with current legislation.

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2 Introduction

2.1 Features

- Standard RJ45 connectivity with support for shielded twisted pair.
- Dual 100Mbps EtherCAT interfaces for use in line topologies i.e. daisy chaining.
- Supports the Unidrive SP drives range, Mentor MP, Affinity, Digitax ST and Commander SK.
- Control loop synchronisation.
- Control cycle times down to 250μs.
- CANopen over EtherCAT (CoE) which includes:
  - Support of CANopen DSP-402 (Device Profile for Drives and Motion)
  - Interpolated position mode
  - Velocity mode
  - Profile torque mode
  - Two transmit and two receive PDOs.
  - SDO access to all profile objects and drive parameters.

2.2 Introduction to SM-EtherCAT

SM-EtherCAT is a Solutions Module that enables the Control Techniques range of variable speed drives to be connected to an EtherCAT network as a slave device. It can be used in a variety of applications, from those requiring accurate synchronization and precise motion control, to those where ease of use and open loop control are appropriate.

2.3 What is EtherCAT?

EtherCAT is an open high performance Ethernet-based fieldbus system that overcomes the system limitations of other Ethernet solutions. The Ethernet packet is no longer received, then interpreted and copied as process data at every connection; instead the Ethernet frame is processed on the fly. The development goal of EtherCAT was to apply Ethernet to automation applications that require short data update times (also called cycle times) with low communication jitter (for synchronization purposes) and low hardware costs. Typical application fields for EtherCAT are machine controls (e.g. semiconductor tools, metal forming, packaging, injection moulding, assembly systems, printing machines, robotics and many others).

2.4 Solution module identification

The SM-EtherCAT can be identified by:

1. The label located on the underside of the Solutions Module.
2. The colour coding across the front of the SM-EtherCAT (brown-red).

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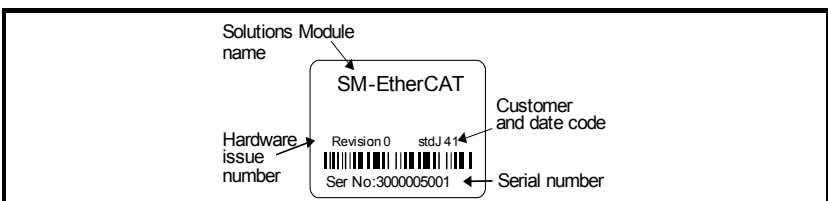
2.4.1 Date code format

The date code is split into two sections: a letter followed by a number.

The letter indicates the year and the number indicates the week number (within the year) in which the Solutions Module was built.

The letters are alphabetical in order, starting with A in 1991 (B in 1992, C in 1993 etc.).

Example:

A date code of Q46 would correspond to week 46 of year 2007.

2.5 Conventions used in this guide

The configuration of the host drive and Solutions Module is done using menus and parameters. A menu is a logical collection of parameters that have similar functionality. In the case of a Solutions Module, the parameters will appear in menu 15 for the Commander SK, in menu 15 or 16 for Affinity and in menu 15, 16 or 17 for the Unidrive SP, Digitax ST and Mentor MP depending on the slot the module is fitted into. The menu is determined by the number before the decimal point. The method used to determine the menu or parameter is as follows:

- Pr **xx.00** - signifies any menu and parameter number 00.
- Pr **MM.xx** - where **MM** signifies the menu allocated to the Solution Module (this could be 15, 16 or 17 on the Unidrive SP, Digitax ST or Mentor MP, 15 or 16 on the Affinity, but will always be 15 on the Commander SK) and **xx** signifies the parameter number.

NOTE All references in this manual to SM-Applications/Plus should also extend to SM-Applications Lite/Lite V2. The exceptions to this are references to SM-Applications/Plus input/output, CTSync or the RS485 port, as these are not supported on SM-Applications Lite/Lite V2. For full details of the differences see the SM-*Applications Modules and Motion Processors User Guide*.

NOTE It is strongly recommended that the latest firmware be used where possible to ensure that all features are supported.

3 Mechanical Installation

Before installing or removing a Solutions Module in any drive, ensure the AC supply has been disconnected for at least 10 minutes and refer to Chapter 1 *Safety Information* on page 5. If using a DC bus supply ensure this is fully discharged before working on any drive or Solutions Module.

3.1 General Installation

The installation of a Solutions Module is illustrated in Figure 3-1.

Figure 3-1 Fitting a Solutions Module
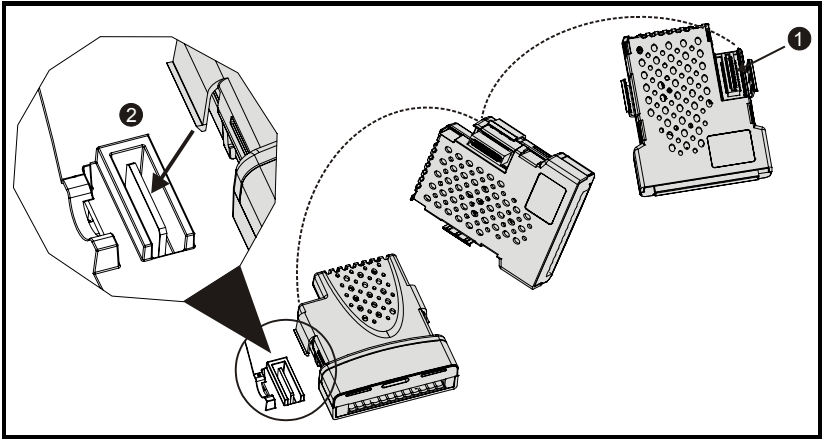
The Solutions Module connector is located on the underside of the module (1). Push this into the Solutions Module slot located on the drive until it clicks into place (2). Note that some drives require a protective tab to be removed from the Solutions Module slot. For further information, refer to the appropriate drive manual.

4 Electrical Installation

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4.1 SM-EtherCAT module information

4.1.1 Bus media

The SM-EtherCAT option module incorporates two x 100 BASE-TX RJ45 interfaces.

4.1.2 Cabling considerations

To ensure long-term reliability it is recommended that any cables used to connect a system together be tested using a suitable Ethernet cable tester, this is of particular importance when cables are constructed on site.

4.1.3 Cable

Cables should be shielded and as a minimum, meet TIA Cat 5e requirements.

NOTE   Cabling issues are the single biggest cause of network downtime. Ensure cabling is correctly routed, wiring is correct, connectors are correctly fitted and any switches or routers used are rated for industrial use. Office grade Ethernet equipment does not generally offer the same degree of noise immunity as equipment intended for industrial use.

4.1.4 Maximum network length

The main restriction imposed on Ethernet cabling is the length of a single segment of cable. The SM-EtherCAT module has two 100BASE-TX Ethernet ports, which support segment lengths of up to 100m. This means that the maximum cable length which can be used between one SM-EtherCAT port and another 100BASE-TX port is 100m however it is not recommended that the full 100m cable length is used. The total network length is not restricted by the Ethernet standard but depends on the number of devices on the network and the transmission media (copper, fiber optic, etc.).

NOTE   The EtherCAT system designer must consider the impact that the selected network structure will have on performance.

4.2 Module grounding

SM-EtherCAT is supplied with a grounding tag on the module that should be connected to the closest possible grounding point using the minimum length of cable. This will greatly improve the noise immunity of the module.

4.3 Network topology

Control Techniques recommend implementing daisy chaining on EtherCAT networks (see Figure 4-1). Other Ethernet network topologies can be used but care must be taken to ensure that the system still operates within the constraints specified by the designer.

Figure 4-1 SM-EtherCAT daisy chain network topology
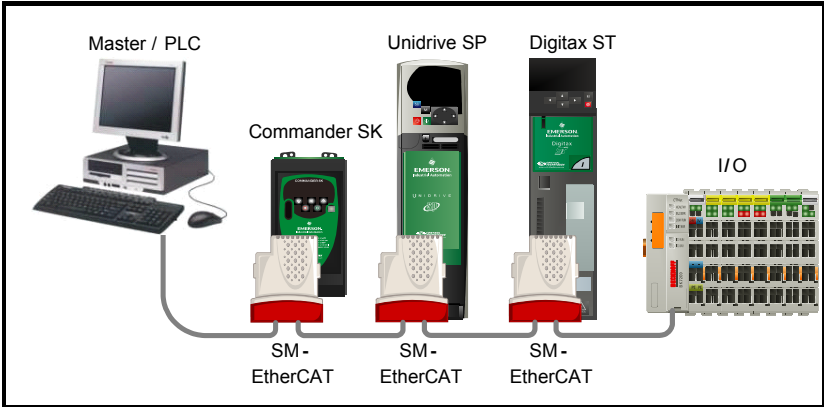
4.4 Minimum node-to-node cable length

There is no minimum length of cable recommended in the Ethernet standards. To avoid possible problems it is recommended that you allow sufficient cable length to ensure good bend radii on cables and avoid unnecessary strain on connectors.

5 Getting Started

5.1 Quick start guide

This section is intended to provide a generic guide for setting up SM-EtherCAT with a master/controller PLC. It will cover the basic steps required to get cyclic data communicating using the CANopen over EtherCAT (CoE) protocol on the SM-EtherCAT module.

5.1.1 SM-EtherCAT version compatibility

Table 5.1 SM-EtherCAT version compatibility

Drive Type	Drive Firmware	SM-EtherCAT firmware
Unidrive SP	V01.08.00 or later	V01.00.00 or later
Affinity	V01.02.00 or later	V01.00.00 or later
Digitax ST	V01.02.00 or later	V01.00.00 or later
Commander SK	V01.06.00 or later	V01.00.00 or later
Mentor MP	V01.00.00 or later	V01.02.00 or later

For the purpose of the example this section will follow the steps required to set up cyclic communications using one RxPDO and two TxPDOs. These PDOs will consist of the mappings shown in Table 5.2:

Table 5.2 PDO test mappings

	RxPDO1	TxPDO1	TxPDO6
Mapping 1	0x6040 (*controlword*) (16-bits)	0x6041 (*statusword*) (16-bits)	Pr **18.22** (16-bits)
Mapping 2	0x6042 (*vl_target_velocity*) (16-bits)	0x6064 (*position_actual_value*) (32-bits)	Pr **20.21** (32-bits)
Mapping 3	Pr **20.21** (32-bits)	N/A	N/A

NOTE   It is strongly recommended that the latest firmware be used where possible to ensure that all features are supported.

Due to the large number of different masters that support CoE, details cannot be provided for a specific master. Generic support is available through your supplier or local Control Techniques Drive Centre. Before contacting your supplier or local Control Techniques Drive Centre for support please ensure you have read *section 9 Diagnostics* on page 56 of this manual and have checked that the SDO/PDO configurations are correct.

5.1.2 SM-EtherCAT XML file

Control Techniques provides an EtherCAT device description file (Control Techniques SM-EtherCAT.xml). This file provides the master with information about the SM-EtherCAT module to aid with its configuration. The file can be downloaded from the Control Techniques CTSupport.com website or from your local Control Techniques Drive Centre or supplier. It should be placed in the directory specified by the master e.g. When using TwinCAT this could be C:\TwinCAT\Io\EtherCAT.

NOTE   The master may have to be re-started for the file to be loaded.

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5.1.3 Configuring the SM-EtherCAT module for cyclic communications

Unlike other Control Techniques fieldbus communication protocols, CoE does not require that any module parameters be changed in order to achieve communications. The baud rate of the network is fixed and the module is automatically allocated an address.

To check that the ethernet cable connected to the SM-EtherCAT module on the drive is connected correctly, look at the LED on the front of the SM-EtherCAT module relating to the connector being used, if this light is a solid green color then a link is established with the master, if this light if off then check the cabling and also check that the master has started communications.

In the master, scan the network ensuring that the SM-EtherCAT module is connected correctly to the master. If the network is configured correctly the SM-EtherCAT node(s) should be visible in the PLC Master.

Decide on the input / output data you wish to send cyclically (objects and/or parameters).

Cyclic data is implemented on CoE networks by using "Process Data Objects" or PDOs. Separate data objects are used for receiving (TxPDOs - from the slave to the master) and transmitting (RxPDOs - from the master to the slave) data.

These PDOs contain the cyclic data (objects and/or parameters), the RxPDOs available are 1, 2, 6 and 22, the TxPDOs available are 1, 2, 3, 6 and 22 (for more information on these PDOs including default mappings please see section 6.1.2 *RxPDO mappings* on page 21 and section 6.1.3 *TxPDO mappings* on page 23).

Figure 5-1 SM-EtherCAT PDO configuration
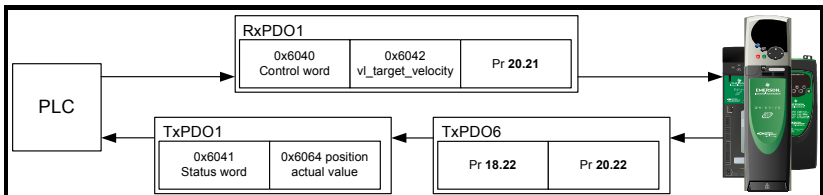
RxPDO1, TxPDO1 and TxPDO6 will need to be enabled in the master. Once enabled you will need to add mappings to the PDOs.

The format used when mapping objects to PDOs is as follows:

- Index: Object index number (0x0000)
- Sub-index: Object sub-index number (0x00)
- Size: Dependant on the size (in bytes) of the object to be mapped (range: 1-4)

The format of mapping drive parameters to PDO is as follows:

- Index: 0x2000 + menu number
- Sub-index: 0x00 + parameter number
- Size: Dependant on the size (in bytes) of the object to be mapped (range: 1-4)

For example Pr **20.21** would be index 0x2014, sub-index 0x15 and the size would be 4 (the parameter is a 32-bit signed value).

NOTE The values are normally expressed in hexadecimal, so care must be taken to enter the correct parameter number.

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For this example the following objects will need to be set in order to achieve the mappings of the parameters/objects in the PDOs.

Table 5.3 Cyclic data mapping configuration

RxPDO1:		TxPDO1:		TxPDO6:	
Object:	0x1600	Object:	0x1A00	Object:	0x1A05
Sub-index:	0x00	Sub-index:	0x00	Sub-index:	0x00
Size:	1	Size:	1	Size:	1
Value:	3	Value:	2	Value:	2
Sub-index:	0x01	Sub-index:	0x01	Sub-index:	0x01
Size:	4	Size:	4	Size:	4
Value:	0x60400010	Value:	0x60410010	Value:	0x20121610
Sub-index:	0x02	Sub-index:	0x02	Sub-index:	0x02
Size:	4	Size:	4	Size:	4
Value:	0x60420010	Value:	0x60640020	Value:	0x20141620
Sub-index:	0x03		Not Used		Not Used	
Size:	4					
Value:	0x20141520					

NOTE The format used to define the value of a mapped object is as follows:
Bit 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap).
Bit 8 to 15: Sub-index of the mapped object (if a gap, zero).
Bit 16 to 31: Index of the mapped object (if a gap, zero).

NOTE The maximum number of mappings in one PDO is five. There are no restrictions on the data length of these 5 parameters (i.e. It is possible to map five, 32-bit parameters in one PDO). It is also possible to use a maximum of 2 x RxPDOs and 2 x TxPDOs.

5.1.4   Configuring the Sync Managers

The Sync manager is used to control the transmission of CANopen PDOs over the EtherCAT network.

The following objects 0x1C12 - Sync manager 2 PDO assignment (RxPDO) and 0x1C13 - Sync manager 3 PDO assignment (TxPDO) are required to assign PDOs to the synchronization task. For the purpose of the example assign one RxPDO to sync manager 2 and two TxPDOs to sync manager 3.

Figure 5-2 SM-EtherCAT sync manager configuration
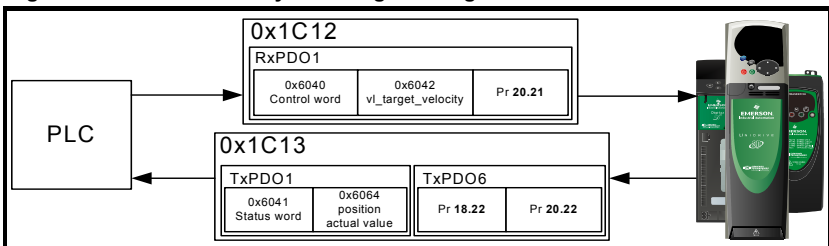
Assigning RxPDO to the Sync Manager

To assign RxPDO1 to sync manager 2 PDO assignment set the values below to the following objects:

- Index: 0x1C12
- Sub index: 0x00
- Size: 1
- Value: 1

Setting object 0x1C12, sub-index 0 to a value of 1 (as above) indicates that one RxPDO will be assigned to the sync manager 2 assignment.

- Index: 0x1C12
- Sub index: 0x01
- Size: 2
- Value: 0x1600

Setting object 0x1C12, sub-index 1 to a value of 0x1600 (as above) maps RxPDO1 to the process data output sync.

Assigning TxPDO to the Sync Manager

To assign TxPDO1 to sync manager 3 PDO assignment set the values below to the following objects:

- Index: 0x1C13
- Sub index: 0x00
- Size: 1
- Value: 2

Setting object 0x1C13, sub-index 0 to a value of 2 (as above) indicates that two TxPDO's will be assigned to the sync manager 3 assignment.

- Index: 0x1C13
- Sub index: 0x01
- Size: 2
- Value: 0x1A00

- Index: 0x1C13
- Sub index: 0x02
- Size: 2
- Value: 0x1A05

Setting object 0x1C13, sub-index 1 to a value of 0x1A00 and sub-index 2 to a value of 0x1A05 (as above) maps TxPDO1 and TxPDO6 to the process data input sync.

Download the configuration to the master.

After downloading the configuration to the master the LED(s) on the front of the SM-EtherCAT should flash, depending on the port(s) connected.

Values written to parameters over RxPDOs should now be viewable using the drive's keypad so long as the master has put the slave into the Operational state; also, parameter values changed using the drive keypad will be updated on the master.

5.2 Quick start flowchart

Figure 5-3 details the steps required to achieve cyclic communications on the EtherCAT network. This flowchart should be used as the starting point for all configurations.

Figure 5-3 Quick start flowchart

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```
                    ┌─────────────────────┐
                    │       START         │
                    └─────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Ensure the Control Techniques .xml file is in the     │
   │ appropriate folder on the hard drive of the master    │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Check the LED status of the SM-EtherCAT module        │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ In the master, scan the EtherCAT network              │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Select required PDOs                                  │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Configure the PDOs with the mappings required         │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Configure the Sync managers using the required  PDOs  │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Download or activate the configuration to the master  │
   └──────────────────────────────────────────────────────┘
                              │
   ┌──────────────────────────────────────────────────────┐
   │ Check the front of the SM-EtherCAT module to ensure   │
   │ that the LED relating to the connection being used is │
   │ flashing this confirms that communications are        │
   │ functioning                                           │
   └──────────────────────────────────────────────────────┘
                              │
                    ┌─────────────────────┐
                    │        END          │
                    └─────────────────────┘
```

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5.3 Saving parameters to the drive

On the Unidrive SP, Affinity, Digitax ST and Commander SK to avoid loss of the configured settings when the drive is powered down it is necessary to write 1000 to Pr **MM.00** followed by pressing the reset button to perform a drive save. On Mentor MP Pr **MM.00** needs to be set to a value of 'SAVE' followed by pressing the reset button.

To store drive parameters:

- Set Pr **MM.00** to 1000 (Mentor MP Pr **MM.00**=SAVE).
- Press the red RESET button.

The drive will store all parameters (except Menu 20) but the operation of the SM-EtherCAT will not be affected. Changes made to the SM-EtherCAT configuration parameters will not take effect until the SM-EtherCAT is reset.

NOTE Unidrive-SP, Mentor MP, Affinity and Digitax ST: Menu 20 applications parameters may be saved if an Application Module is fitted, menu 20 is stored in the Application Module's memory. See the relevant Application Module documentation for more information. If the drive is running on backup supply only, Pr **MM.00** must be set to 1001 to perform a save.

NOTE This saves only drive and module parameters and not SM-EtherCAT related objects.

5.4 Re-initialising the SM-EtherCAT

Table 5.4 SM-EtherCAT re-initialise

SM-EtherCAT re-initialise		
Pr **MM.32**	Default	0 (OFF)
	Range	0 (OFF) to 1 (ON)
	Access	RW

Changes to the SM-EtherCAT configuration in menu 15, 16 or 17 parameters (menu 15 and 16 on Affinity, menu 15 on Commander SK) will not take effect until the SM-EtherCAT has been re-initialised.

To re-initialise SM-EtherCAT:

1. Set Pr **MM.32** to ON.
2. When the sequence has been completed, Pr **MM.32** will be reset to OFF.
3. The SM-EtherCAT will re-initialise using the updated configuration.

NOTE The above sequence does NOT store the SM-EtherCAT configuration parameters in the drive or the SM-EtherCAT's internal FLASH memory. This parameter will change back to off immediately and as such the change may not be visible on the display.

5.5 Re-initialise all Solutions Modules

To re-initialise all Solutions Modules fitted on a Unidrive SP, Affinity or Digitax ST:

1. Set Pr **MM.00** to 1070.
2. Press the red RESET button on the drive.

NOTE This sequence does NOT store the SM-EtherCAT configuration parameters in the drive or the SM-EtherCAT FLASH memory.

NOTE On Commander SK drives, **Pr 00.00** is not available.

6 Protocols

6.1 CANopen over EtherCAT (CoE)

The CoE protocol over EtherCAT uses a modified form of the CANopen object dictionary. This is specified in Table 6.1:

Table 6.1 CoE object dictionary

Index	Object dictionary area
0x0000 to 0x0FFF	Data type area
0x1000 to 0x1FFF	CoE communication area
0x2000 to 0x5FFF	Manufacturer specific area
0x6000 to 0x9FFF	Profile area
0xA000 to 0xFFFF	Reserved area

The object description format describes object related information such as size, range and descriptions and is detailed in Table 6.2:

Table 6.2 Object description format

<index>	<object name>		
Access: <access>	**Range:** <range>	**Size:** <size>	**Unit:** <unit>
Default: <default>			
Description: <description>			

For entries having sub-indices:

Table 6.3 Object description format with sub-indices

<index>	<object name>		
Sub-index 0			
Access: <access>	**Range:** <range>	**Size:** <size>	**Unit:** <unit>
Default: <default>			
Description: <description>			
Sub-index 1			
Access: <access>	**Range:** <range>	**Size:** <size>	**Unit:** <unit>
Default: <default>			
Description: <description>			
...			
Access: <access>	**Range:** <range>	**Size:** <size>	**Unit:** <unit>
Default: <default>			
Description: <description>			
Sub-index n-1			
Access: <access>	**Range:** <range>	**Size:** <size>	**Unit:** <unit>
Default: <default>			
Description: <description>			
Sub-index n			
Access: <access>	**Range:** <range>	**Size:** <size>	**Unit:** <unit>
Default: <default>			
Description: <description>			

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Definitions:

- <index> : A signed 16-bit number. This is the index of the object dictionary entry specified in four hexadecimal characters.
- <access> : A value describing how the object may be accessed (RW = read/write, RO = read-only and WO = write-only).
- <size> : The size of the object/sub-index in bytes.
- <unit> : The physical unit (e.g. ms, counts per second etc.).

6.1.1 CoE communication area

The first set of objects specify general communication settings.

Table 6.4 Device type object

0x1000	Device type			
Access: RO	**Range:** N/A		**Size:** 4 bytes	**Unit:** N/A
Default:	0x00030192			
Description:	The primary CoE functional profile is DSP-402, the value of the object is defined as follows: Bits 0 to 15 (Device profile number): 402 (0x192) Bit 16 (Frequency converter): x Bit 17 (Servo drive): y Bit 18 (Stepper motor): 0 Bit 24 (DC drive - manufacturer specific : z Bits 25 to 31 (Manufacturer specific): 0 This value will depend on the drive operating mode and/or type. On a Unidrive SP in open-loop or closed-loop mode or a Mentor MP in closed-loop mode, bit 16 will be set, while bits 17 and 24 will be cleared. On a Unidrive SP in Servo mode or a Digitax ST, bit 17 will be set, while bits 16 and 24 will be cleared.			

Table 6.5 Identity object

0x1018	Identity object			
Sub-index 0				
Access: RO	**Range:** N/A		**Size:** 1 byte	**Unit:** N/A
Default:	4			
Description:	The number of the last sub-index in this object.			
Sub-index 1				
Access: RO	**Range:** N/A		**Size:** 4 bytes	**Unit:** N/A
Default:	0x000000F9			
Description:	This contains the EtherCAT Technology Group vendor ID for Control Techniques (0x000000F9).			
Sub-index 2				
Access: RO	**Range:** N/A		**Size:** 4 bytes	**Unit:** N/A
Default:	See Pr **MM.01**.			
Description:	This has the value of the option ID code.			
Sub-index 3				
Access: RO	**Range:** N/A		**Size:** 4 bytes	**Unit:** N/A
Default:	High word: Pr **MM.02**. Low word: Pr **MM.51**.			
Description:	Contains the option module software version number (the major and minor version parameter are placed in the high word of this object, and the sub-version parameter is the low word).			
Sub-index 4				
Access: RO	**Range:** N/A		**Size:** 4 bytes	**Unit:** N/A
Default:	See Pr **MM.35**.			
Description:	Contains the option hardware serial number.			

6.1.2 RxPDO mappings

Objects with indices from 0x1600 to 0x17FF specify receive PDO mappings. The mappings from DSP-402 are included as standard (the PDO mappings will have the following default values):

Table 6.6 RxPDO mappings

PDO number	Mapping object index	Mapping object name
1	0x6040	*controlword*
2	0x6040 0x6060	*controlword* *modes of operation*
6	0x6040 0x6042	*controlword* *vl_target _velocity*

The RxPDO mappings objects are defined below. Each mapping object has the maximum number of sub-indices (each representing an object mapped to a PDO) defined in the XML configuration file (specified as "CF" in the descriptions below).

Table 6.7 RxPDO mapping 1

0x1600	Receive PDO mapping 1		
Sub-index 0: Number of mapped objects			
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte	**Unit:** N/A
Default:	1		
Description:	The number of mapped objects in thie PDO		
Sub-index 1: 1st mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default:	0x60400010 - the DSP-402 control word (0x6040)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

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Table 6.8 RxPDO mapping 2

0x1601	Receive PDO mapping 2		
Sub-index 0: Number of mapped objects			
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte	**Unit:** N/A
Default: 2			
Description: The number of mapped objects in this PDO.			
Sub-index 1: 1st mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default: 0x60400010 - the DSP-402 control word (0x6040)			
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			
Sub-index 2: 2nd mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default: 0x60600008 - the DSP-402 modes of operation object (0x6060)			
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

Table 6.9 RxPDO mapping 6

0x1605	Receive PDO mapping 6		
Sub-index 0: Number of mapped objects			
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte	**Unit:** N/A
Default: 2			
Description: The number of mapped objects in this PDO.			
Sub-index 1: 1st mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default: 0x60400010 - the DSP-402 control word (0x6040)			
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			
Sub-index 2: 2nd mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default: 0x60600008 - the DSP-402 modes of operation object (0x6060)			
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

Table 6.10 RxPDO mapping 22

0x1615	Receive PDO mapping 22			
Sub-index 0: Number of mapped objects				
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte		**Unit:** N/A
Default:	0			
Description:	The number of mapped objects in thie PDO			
Sub-indices 1 to 255: 1st to 255th mapped objects in this PDO.				
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes		**Unit:** N/A
Default:	0			
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

6.1.3 TxPDO mappings

Objects with the indices from 0x1A00 to 0x1BFF specify transmit PDO mappings. The following mappings from DSP-402 are included as standard:

Table 6.11 TxPDO mappings

PDO number	Mapping object index	Mapping object name
1	0x6041	*statusword*
2	0x6041 0x6061	*statusword* *modes_of_operation_display*
3	0x6041 0x6064	*statusword* *position_actual_value*
6	0x6041 0x6044	*statusword* *vl_velocity_actual_value*

The PDO mapping objects are defined below. Each mapping object has the maximum number of sub-indices (each representing an object mapped to a PDO) defined in the XML configuration file.

Table 6.12 TxPDO mapping 1

0x1A00	Transmit PDO mapping 1			
Sub-index 0: Number of mapped objects				
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte		**Unit:** N/A
Default:	1			
Description:	The number of mapped objects in thie PDO			
Sub-index 1: 1st mapped object				
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes		**Unit:** N/A
Default:	0x60410010 - the DSP-402 status word (0x6041)			
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

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Table 6.13 TxPDO mapping 2

0x1A01	Transmit PDO mapping 2		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	Size: 1 byte	Unit: N/A
Default:	2		
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60410010 - the DSP-402 status word (0x6041)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60610008 - the DSP-402 modes of operation display object (0x6061)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

Table 6.14 TxPDO mapping 3

0x1A02	Transmit PDO mapping 3		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	Size: 1 byte	Unit: N/A
Default:	2		
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60410010 - the DSP-402 status word (0x6041)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60640020 - the DSP-402 actual position (0x6064)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

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Table 6.15 TxPDO mapping 6

0x1A05	Transmit PDO mapping 6		
Sub-index 0: Number of mapped objects			
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte	**Unit:** N/A
Default:	2		
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default:	0x60410010 - the DSP-402 status word (0x6041)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		
Sub-index 2: 2nd mapped object			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default:	0x60440010 - the DSP-402 vl_control_effort (0x6044).		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

Table 6.16 TxPDO mapping 22

0x1A15	Transmit PDO mapping 22		
Sub-index 0: Number of mapped objects			
Access: RW	**Range:** 0 to (CF)	**Size:** 1 byte	**Unit:** N/A
Default:	0		
Description:	The number of mapped objects in thie PDO		
Sub-indices 1 to 255: 1st to 255th mapped objects in this PDO.			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** 4 bytes	**Unit:** N/A
Default:	0		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

6.1.4   Sync manager configuration

The sync managers are the EtherCAT means for setting access attributes for different areas of memory and triggering or notifying the application when the memory is accessed. The following objects specify how the sync managers (and thus corresponding memory areas) are utilised by the CoE protocol.

Table 6.17 Sync manager communication type object

0x1C00	Sync manager communication type		
Sub-index 0 - number of sync manager channels used			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	4		
Description:	The number of sync manager protocols used by the CoE protocol.		
Sub-index 1 - Usage of sync manager 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	1		
Description:	Sync manager 0 is used by CoE as the mailbox receive channel (master to slave).		
Sub-index 2 - Usage of sync manager 1			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2		
Description:	Sync manager 1 is used by CoE as the mailbox send channel (slave to master).		
Sub-index 3 - Usage of sync manager 2			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	3		
Description:	Sync manager 2 is used by CoE as the process data output (RxPDOx - master to slave).		
Sub-index 4 - Usage of sync manager 3			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	4		
Description:	Sync manager 3 is used by CoE as the process data input (TxPDOs - slave to master).		

Table 6.18 Sync manager 0 PDO assignment object

0x1C10	Sync manager 0 PDO assignment		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	0		
Description:	Number of assigned PDOs. The mailbox received sync manager can never have PDOs assigned to it.		

Table 6.19 Sync manager 1 PDO assignment object

0x1C11	Sync manager 1 PDO assignment		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	0		
Description:	Number of assigned PDOs. The mailbox send sync manager can never have PDOs assigned to it.		

Table 6.20 Sync manager 2 PDO assignment object

0x1C12	Sync manager 2 PDO assignment		
Sub-index 0			
Access: RW	**Range:** 0 to 512	**Size:** 1 byte	**Unit:** N/A
Default: 1			
Description:	The number of RxPDOs assigned to this sync manager (used for process data output).		
Sub-indices 1 to (sub-index 0)			
Access: RW	**Range:** 0x1600 to 0x17FF	**Size:** 2 bytes	**Unit:** N/A
Default: 0x1605			
Description:	The object index of an RxPDO to assign to this sync manager. By default this is assigned to RxPDO mapping 6 (vl_target_velocity and controlword).		

Table 6.21 Sync manager 3 PDO assignment object

0x1C13	Sync manager 3 PDO assignment		
Sub-index 0			
Access: RW	**Range:** 0 to 512	**Size:** 1 byte	**Unit:** N/A
Default: 1			
Description:	The number of TxPDOs assigned to this sync manager (used for process data input).		
Sub-indices 1 to (sub-index 0)			
Access: RW	**Range:** 0x1A00 to 0x1BFF	**Size:** 2 bytes	**Unit:** N/A
Default: 0x1A05			
Description:	The object index of an TxPDO to assign to this sync manager. By default this is assigned to TxPDO mapping 6 (vl_velocity_actual_value and statusword).		

6.1.5 Feedback encoder source

Table 6.22 Feedback encoder source

0x2802	Feedback encoder source		
Sub-index 0			
Access: RW	**Range:** 0 to 3	**Size:** 1 byte	**Unit:** N/A
Default: 0			
Description:	This object specifies the source position for position controller feedback.		

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7 Drive profile (DSP-402) support

SM-EtherCAT supports the following modes of the DSP-402 profile:

- Interpolated position mode
- vl velocity mode
- Profile torque mode

7.1 0x6040 Controlword

This provides the primary method of controlling the behavior of the drive e.g. enabling, disabling, resetting, etc. Table 7.1 describes the format of the control word. The individual bits are used in combinations (see Table 7.2) to sequence the drive through the state machine described in Figure 7-1.

Table 7.1 Controlword

0x6040	Controlword		
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: N/A
Default:	N/A		
Description:	Provides the primary method of controlling the behavior of the drive.		

Table 7.2 Controlword bit functions

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Reserved					r	oms	h	fr	oms		hos	eo	qs	ev	so

LEGEND: ms = manufacturer-specific; r = reserved; oms = operation mode specific; h = halt; fr = fault reset; hos = homing operation start; eo = enable operation; qs = quick stop; ev = enable voltage; so = switch on

Table 7.3 Command coding

Command	Bits of the controlword				
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0
Shutdown	0	X	1	1	0
Switch on	0	0	1	1	1
Switch on + enable operation	0	1	1	1	1
Disable voltage	0	X	X	0	X
Quick stop	0	X	0	1	X
Disable operation	0	0	1	1	1
Enable operation	0	1	1	1	1
Fault reset	⌐̲	X	X	X	X
NOTE: Automatic transition to Enable operation state after executing SWITCHED ON state functionality.					

7.2 0x6041 Statusword

This provides feedback about the current operating state of the drive. Table 7.4 describes the format of the status word and illustrates how the individual statusword bits are combined to represent the current state of the drive.

Table 7.4 Statusword

0x6041	Statusword		
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: N/A
Default:	N/A		
Description:	This provides feedback about the current operating state of the drive.		

Table 7.5 Statusword bit functions

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ms			ha	lla	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso

LEGEND: ms = manufacturer-specific; ha = homing attained; oms = operation mode specific; ila = internal limit active; tr = target reached; rm = remote; w = warning; sod = switch on disabled; qs = quick stop; ve = voltage enabled; f = fault; oe = operation enabled; so = switched on; rtso = ready to switch on

Table 7.6 State coding

Statusword	State
xxxx xxxx x0xx 0000b	Not ready to switch on
xxxx xxxx x1xx 0000b	Switch on disabled
xxxx xxxx x01x 0001b	Ready to switch on
xxxx xxxx x01x 0011b	Switched on
xxxx xxxx x01x 0111b	Operation enabled
xxxx xxxx x00x 0111b	Quick stop active
xxxx xxxx x0xx 1111b	Fault reaction active
xxxx xxxx x0xx 1000b	Fault

7.3 Common profile features

7.3.1 Sequencing control

These are the supported objects used to control the drive:

Table 7.7 Sequencing control supported objects

Index	Name
0x6040	*controlword*
0x6041	*statusword*
0x605B	*shutdown_option_code*
0x605C	*disable_operation_option_code*
0x605A	*quick_stop_option_code*
0x605D	*halt_option_code*
0x605E	*fault_reaction_option_code*
0x6060	*modes_of_operation*
0x6061	*modes_of_operation_display*
0x6085	*quick_stop_deceleration*

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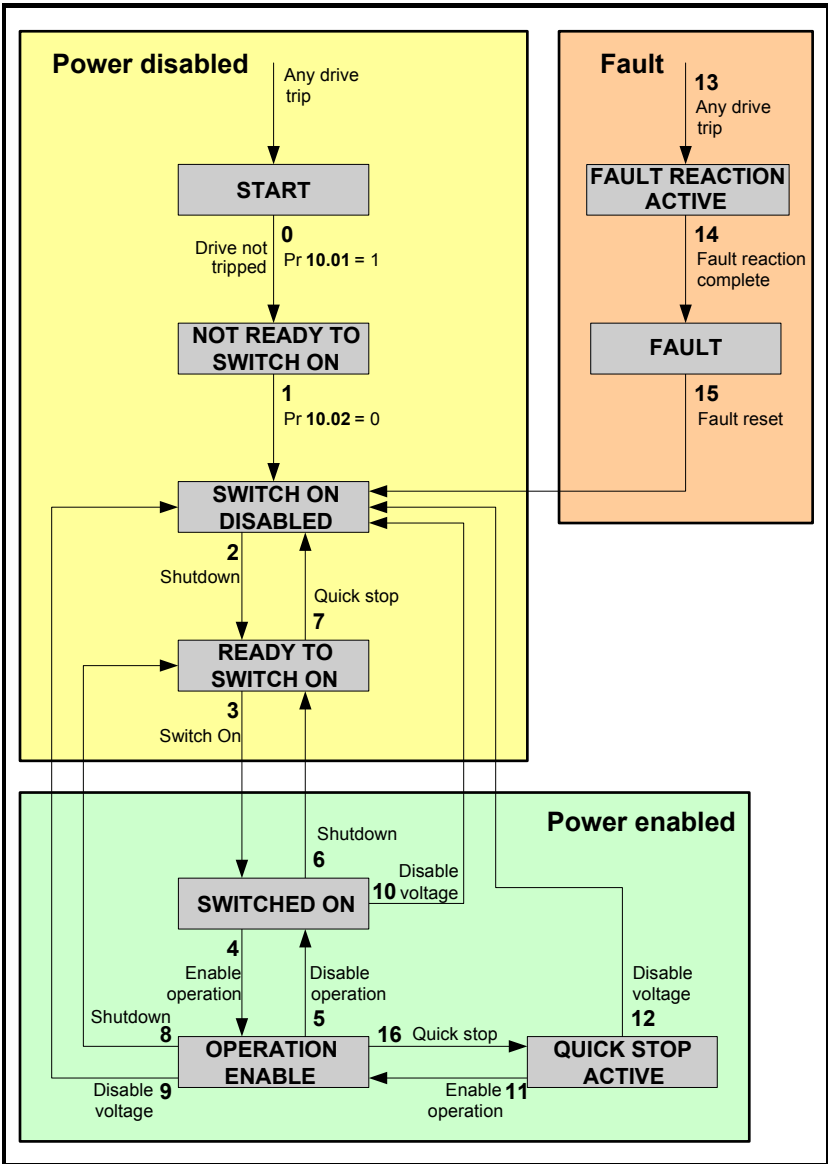Quick Reference

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The behavior of the sequencing control is shown in Figure 7-1 *CoE state machine diagram* . This state machine indicates how the drive will be controlled. For clarity the Statusword is abbreviated to 'SW' in the diagram.

When in the 'QUICK STOP ACTIVE' state, the currently selected mode of operation indicates how a quick stop function should be handled. When the drive is stopped, and the Quick stop option code doesn't indicate that the state should remain at 'QUICK STOP ACTIVE', the state will move to 'SWITCH ON DISABLED'.

When in the 'OPERATION ENABLED' or 'QUICK STOP ACTIVE' states it is not possible to change the *mode_of_operation* object. This is to ensure that the motor is stopped before changing the operation mode.

The SM-EtherCAT master device must be in the operational state before the state machine can move from the 'SWITCH ON DISABLED' state to the 'READY TO SWITCH ON' state. If the master leaves the operational state while the state machine is in the 'SWITCH ON', 'OPERATION ENABLE' , 'QUICK STOP ACTIVE' or 'READY TO SWITCH ON' state then the option will transition to the 'SWITCH ON DISABLED' state. This implies that the drive will be inhibited and the motor will coast.

Figure 7-1 CoE state machine diagram

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Table 7.8 CoE state machine transition and events

Transition	Event(s)	Action(s)
0	Automatic transition after power-on or reset application	Drive device self-test and/or self initialisation shall be performed
1	Automatic transition	Communication shall be activated
2	Shutdown command from control device or local signal	None
3	Switch on command received from control device or local signal	Power section shall be switched on if not already switched on
4	Enable operation command received from control device or local signal	Drive function shall be enabled and clear all internal set-points
5	Disable operation command received from control device or local signal	Drive function shall be disabled
6	Shutdown command received from control device or local signal	The high-power shall be switched-off immediately, and the motor shall be free to rotate if not braked; additional action depends on the shutdown option code
7	Quick stop or disable voltage command from control device or local signal	None
8	Shutdown command from control device or local signal	The high-power shall be switched off immediately if possible, and the motor shall be free to rotate if not braked
9	Disable voltage command from control device or local signal	The high-power shall be switched off immediately if possible, and the motor shall be free to rotate if not braked
10	Disable voltage or quick stop command from control device or local signal	The high-power shall be switched off immediately if possible, and the motor shall be free to rotate if not braked
11	Quick stop command from control device or local signal	The quick stop function shall be started
12	Automatic transition when the quick stop function is completed and quick stop option code 1, 2, 3 or 4 disable voltage command received from control device (dependant on the quick stop option code)	The power section shall be switch off
13	Fault signal	The configure fault reaction function shall be executed
14	Automatic transition	The drive function shall be disabled; the high-power may be switched off
15	Fault reset command from control device or local signal	A reset of the fault condition is carried out, if no fault exists currently on the drive device; after leaving the Fault state, the Fault reset bit in the controlword shall be cleared by the control device
16	Enable operation command from control device, if the quick stop option code is 5, 6, 7 or 8	The drive function shall be enabled

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When the SM-EtherCAT module transitions from the EtherCAT Safe-operational state to the EtherCAT Operational state, a number of drive parameters are set to allow the CoE profiles to control the drive and motor (unless object 0x2805 has been set to disable this). These parameters are set in the following order:

- Pr **6.42** to 0
- Pr **6.43** to On
- Pr **3.22** to 0 (where present)
- Pr **3.23** to On (where present)
- Pr **3.13** to Off (In open-loop operating modes)
- Pr **2.10** to 1
- Pr **2.20** to 1
- Pr **2.02** to On
- Pr **1.04** to 0
- Pr **1.21** to 0
- Pr **1.38** to 0
- Pr **1.08** to Off
- Pr **1.10** to On
- Pr **1.09** to Off
- Pr **1.15** to 1
- Pr **1.14** to 3

These values are set once and not continuously forced. They are not reset when leaving the Operational state. In addition, the option starts to write parameters implicitly mapped by the CoE profiles, when moving to the Operational state.

7.3.2 0x605A Quick stop option code

This object indicates what action is perfomed when the quick stop function is executed. The slow down ramp is the deceleration value of the used mode of operations.

Table 7.9 Quick_stop_option_code

0x605A	Quick_stop_option_code			
Access: RW	**Range:** 0 to 6	**Size:** Unsigned 16	**Unit:** N/A	
Default:	2			
Description:	Specifies what action is performed in the event of a quick stop function. See Table 7.8 CoE state machine transition and events for more information.			

Table 7.10 Quick stop value definitions

Value	Definition
0	Disable drive function
1	Slow down on slow down ramp and transit into Switch on disabled
2	Slow down on quick stop ramp and transit into Switch on disabled
5	Slow down on slow down ramp and stay in Quick stop active
6	Slow down on quick stop ramp and stay in Quick stop active

7.3.3 0x605B Shutdown_option_code

This object is used to control what action is performed if there is a transition from the Operation Enabled state to the Ready To Switch On state.

Table 7.11 Shutdown_option_code

0x605B	Shutdown_option_code		
Access: RW	**Range:** 0 to 1	**Size:** Unsigned 16	**Unit:** N/A
Default:	N/A		
Description:	Used to control what action is performed if there is a transition from the Operation Enabled state to the Ready To Switch On state.		

Table 7.12 Shutdown_option_code values

Value	Definition
0	Disable drive function (switch-off the drive power stage)
1	Slow down with slow down ramp; disable the drive function

7.3.4 0x605C Disable_operation_option_code

Disable drive function (switch-off the drive power stage).

This object is used to control what action is performed if there is a transition from the 'Operation Enabled' state to the 'Switched On' state.

Table 7.13 Disabled_operation_option_code

0x605C	Disable_operation_option_code		
Access: RW	**Range:** 0 to 1	**Size:** Unsigned 16	**Unit:** N/A
Default:	N/A		
Description:	This object is used to control what action is performed if there is a transition from the Operation Enabled state to the Switched On state.		

Table 7.14 Disable_operation_option_code values

Value	Definition
0	Disable drive function (switch-off the drive power stage)
1	Slow down with slow down ramp; disable the drive function

7.3.5 0x605E Fault_reaction_option_code

This object is used to control what action is performed when a fault is detected. This object is ignored if the drive is tripped.

Table 7.15 Fault_reaction_option_code

0x605E	Fault_reaction_option_code		
Access: RW	**Range:** 0 to 2	**Size:** Unsigned 16	**Unit:** N/A
Default:	N/A		
Description:	This object is used to control what action is performed when a fault is detected.		

Table 7.16 Fault_reaction_option_code values

Value	Definition
0	Disable drive function, motor is free to rotate
1	Slow down on slow down ramp
2	Slow down on quick stop ramp

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7.3.6 0x6060 Modes_of_operation

This object is used to request a change in the mode of operation.

Table 7.17 Modes_of_operation

0x6060	Modes_of_operation		
Access: RW	Range: 0 to 7	Size: Unsigned 8	Unit: N/A
Default:	2		
Description:	This object is used to request a change in the mode of operation.		

Table 7.18 Modes_of_operation values

Value	Definition
0	No mode change
2	vl velocity mode
4	Profile torque mode
6	Homing mode
7	Interpolated position mode

7.3.7 0x6061 Modes_of_operation_display

This read only object indicates the active mode of operation.

Table 7.19 Modes_of_operation_display

0x6061	Modes_of_operation_display		
Access: RO	Range: 0 to 7	Size: Unsigned 8	Unit: N/A
Default:	N/A		
Description:	Used to provide the active mode of operation.		

Table 7.20 Modes_of_operation_display values

Value	Definition
0	No mode change
2	vl velocity mode
4	Profile torque mode
6	Homing mode
7	Interpolated position mode

7.3.8 0x6085 Quick_stop_deceleration

This object is used to configure the deceleration rate used to stop the motor when the quick stop function is activated and the quick stop code object (0x605A) is set to 2 or 6. The quick stop deceleration is also used if the fault reaction code object (0x605E) is 2. The value is given in user-defined acceleration units.

Table 7.21 Quick_stop_deceleration

0x6085	Quick_stop_deceleration		
Sub-index 0			
Access: RW	Range:0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default:	2		
Description:	Quick stop function for the positioning related modes.		

7.3.9 Profile units

The implementation provides a means to convert profile units into position controller and drive units. All scaling values are standard profile objects. The following objects are supported:

Table 7.22 Supported profile units

Index	Name
0x608F	*position_encoder_resolution*
0x6091	*gear_ratio*
0x6092	*feed_constant*

For positions, the scaling control includes a feed constant, a gear ratio and an encoder revolution. These values are combined by the implementation into a simple scaling numerator and denominator. It is possible to change these values non-cyclically (i.e. using SDOs), in which case the scaling numerator and denominator and any position limit values are recalculated in the background. It is not, however, possible to change these values cyclically (i.e. by mapping PDOs to them).

For velocities, in addition to the position constants described above. These values are combined into a simple numerator and denominator to scale velocities to internal velocity units. This scaling also properly handles remainders (i.e. when used on a reference or feedback, accumulate the remainder and add it to subsequent velocity values, and when used with a limit, round up or down). It is possible to change these values non-cyclically (i.e. using SDOs), in which case the scaling numerator and denominator is recalculated in the background. It is also necessary to re-scale velocity limit values with the new factor. It is not possible to change these values cyclically (i.e. by mapping PDOs to them).

7.3.10 0x608F Position_encoder_resolution

This read only object indicates the configured encoder increments per number of motor revolutions. The information is read from the drive's encoder configuration.

Table 7.23 Position_encoder_resolution

0x608F	Position_encoder_resolution		
Sub-index 0			
Access: RO	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default: 2			
Description:			
Sub-index 1			
Access: RO	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default: 1			
Description: Encoder increments			
Sub-index 2			
Access: RO	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default: 1			
Description: Motor revolutions			

7.3.11 0x6091 Gear_ratio

This object is used to apply scaling. When configured, appropriate user units can be used to control the position of the shaft beyond a gearbox. The gear ratio is calculated using the following formula:

gear ratio = motor shaft revolutions / driving shaft revolutions

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Table 7.24 Gear_ratio

0x6091	Gear_ratio			
Sub-index 0				
Access: RO		**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2			
Description:				
Sub-index 1				
Access: RW		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	1			
Description:	Motor revolutions			
Sub-index 2				
Access: RW		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	1			
Description:	Shaft revolutions			

7.3.12 0x6092 Feed_constant

This is used to configure a feed constant. This is the measurement distance per one revolution of the output shaft of the gearbox. The feed constant is calculated using the following formula:

feed constant = feed / driving shaft revolutions

The feed should be provided in user-defined position units

Table 7.25 Feed_constant

0x6092	Feed_constant			
Sub-index 0				
Access: RO		**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2			
Description:				
Sub-index 1				
Access: RW		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	1			
Description:	Feed			
Sub-index 2				
Access: RW		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	1			
Description:	Shaft revolutions			

7.3.13 Basic position control

Basic position control is supported on the Unidrive SP in servo mode, closed-loop vector mode and RFC mode. It works on the Digitax ST and Mentor MP but is not supported in open-loop or regen mode on any of the drives. If is also not available on Commander SK or Affinity. The position control described here is used under the interpolated position mode of operation.

Table 7.26 lists the objects that are supported:

Table 7.26 Basic position control supported objects

Index	Name
0x6062	*position_demand_value*
0x6064	*position_actual_value*
0x6065	*following_error_window*
0x6067	*position_window*
0x60F4	*following_error_actual_value*
0x60FB	*position_control_parameter_set*

7.3.14 0x6062 Position_demand_value

This read only object is used to provide the currently demanded position value. The value is given in user defined position units.

Table 7.27 Position_demand_value

0x6062	Position_demand_value			
Access: RO		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	N/A			
Description:	Used to provide the currently demanded position value.			

7.3.15 0x6064 Position_actual_value

This read only object provides the actual value of the position feedback device. The value is given in internal units.

Table 7.28 Position_actual_value

0x6064	Position_actual_value			
Access: RO		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	N/A			
Description:	This read only object provides the actual value of the position feedback device. The value is given in internal units.			

7.3.16 0x60F4 Following_error_actual_value

This read only object provides the actual value of the following error. The value is given in user-defined position units.

Table 7.29 Following_error actual_value

0x60F4	Following_error actual_value			
Access: RO		**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	N/A			
Description:	This read only object provides the actual value of the following error.			

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7.3.17 0x60FB Position_control_parameter_set object

Table 7.30 Position_control_parameter_set object

0x60FB	Position_control_parameter_set		
Sub-index 0			
Access: RO	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2		
Description:	The number of control loop parameters.		
Sub-index 1			
Access: RW	**Range:** 0 to 65535	**Size:** Unsigned 16	**Unit:** 0.01 rad/s/rad
Default:	2500		
Description:	The position controller proportional gain.		
Sub-index 2			
Access: RW	**Range:** 0 to 65535	**Size:** Unsigned 16	**Unit:** 1 / 1000
Default:	1000 (i.e. a gain of 1)		
Description:	The position controller speed feed forward gain.		

The APC position controller kernel is used by the basic internal position control.

The *position_demand_value* object contains the value supplied by either the interpolated position mode or the profile position mode (in user units). It is updated every control loop cycle. This object can be mapped as cyclic data.

7.4   Interpolated position mode

Interpolated position mode operates on the Unidrive SP in servo mode, closed-loop vector mode and RFC mode. This mode also operates on the Digitax ST and Mentor MP. Table 7.31 lists the objects that are supported:

Table 7.31 Supported Interpolated position mode objects

Index	Name
0x60C0	*interpolation_submode_select*
0x60C1	*interpolation_data_record*
0x60C2	*interpolation_time_period*

7.4.1   0x60C0 Interpolation_sub-mode_select

Table 7.32 0x60C0 Interpolation_sub-mode_select

0x60C0	Interpolation_sub-mode_select		
Access: RW	**Range:** 0	**Size:** Signed 16	**Unit:** N/A
Default:	0 (Linear interpolation)		
Description:	Specifies the interpolation type. The values have the following meanings:0 = Linear Interpolation.		

7.4.2 0x60C1 Interpolation_data_record

This object is used to specify the target position. Linear interpolation is used to generate position demand values every 250µs. The position is specified in user-defined position units. The value is written into sub-index 1.

Table 7.33 0x60C1 Interpolation_data_record

0x60C1	Interpolation_data_record		
Sub-index 0			
Access: RO	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	1		
Description:	This object is used to specify the target position.		
Sub-index 1			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** N/A
Default:	N/A		
Description:	The set-point		

7.4.3 0x60C2 Interpolation_time_period

Table 7.34 Interpolation_time_period

0x60C2	Interpolation_time_period		
Sub-index 0			
Access: RO	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2		
Description:	The number of last sub-indexes in this object.		
Sub-index 1			
Access: RW	**Range:** 0 to 255	**Size:** Unsigned 8	**Unit:** (sub-index 2)
Default:	250 (units are dependant on the value in sub-index 2)		
Description:	The number of time units between interpolator re-starts. A time unit is defined by sub-index 2. The interpolator time period value is checked to ensure that it is valid. Valid values are 250µs, 500µs or any multiple of 1ms. An attempt to write other values results in an SDO Abort code.		
Sub-index 2			
Access: RW	**Range:** -6 to 0	**Size:** Signed 8	**Unit:** N/A
Default:	-6 (a time unit of 1µs)		
Description:	This specifies the time unit for the interpolation time period. Sub-index 2 specifies the unit exponent. The time unit, therefore, is 10(sub-index 2). The range of values allows for the shortest time unit to be 1µs, and the longest to be 1s.		

The implementation of interpolated position mode allows synchronous operation only, where a fixed, common interpolation interval is defined. The time specified must always be an integer multiple of the control loop cycle time. The time period index has a minimum value of -6 (i.e. the smallest time unit will be microseconds), see Table 7.35 for more information.

Table 7.35 Interpolation time period units

Value in 0x60C2, sub-index 2	Description
0	1 second
-1	0.1 of a second
-2	0.01 of a second
-3	0.001 of a second
–4	0.0001 of a second
–5	0.00001 of a second
-6	0.000001 of a second

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The time period is checked to ensure that it is an integer multiple of the control loop cycle time. Only linear interpolation is currently supported. This type inserts a delay of one interpolation time period.

The input buffer has a maximum size of 1 data record, and a data record contains one position in profile-defined units. The buffer is a FIFO buffer. Every interpolator time period, a value is read from this buffer. The correct number of data points for a specific interpolation mode are stored internally. When a new position command is loaded in, the oldest position command in the data set is discarded.

7.5 vl velocity mode

Velocity mode is supported on Unidrive SP, Digitax ST, Affinity, Mentor MP and Commander SK. It is not, however, supported in regen modes. This mode uses the drive's speed handling and ramps.

When the attached drive is in either of the closed-loop or servo operating modes the scaled velocity is written to the drive internal speed shortcut. When the attached drive is in an open-loop operating mode the scaled velocity is written to the user preset reference parameter (Pr **1.21**). Table 7.36 lists the objects that are supported:

Table 7.36 vl velocity mode supported objects

Index	Name
0x6042	*vl_target_velocity*
0x6043	*vl_velocity_demand*
0x6044	*vl_velocity_actual_value*
0x6046	*vl_velocity_min_max_amount*
0x6047	*vl_velocity_min_max*
0x6048	*vl_velocity_accleration*
0x6049	*vl_velocity_deceleration*
0x604A	*vl_velocity_quick_stop*
0x604B	*vl_setpoint_factor*
0x604C	*vl_dimension_factor*

7.5.1 0x6042 vl_target_velocity

This object is used to set the required velocity of the system. It is multiplied by the vl_dimension_factor and the vl_setpoint_factor. The value is given in rpm, If the vl_dimension_factor has the value of 1, otherwise the value is in user units. Positive values indicate forward direction and negative values indicate reverse direction.

Table 7.37 vl_target_velocity

0x6042	vl_target_velocity		
Access: RW	**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** rpm
Default:	0		
Description:	Used to set the required velocity of the system.		

7.5.2 0x6043 vl_velocity_demand

This read only object provides the instantaneous velocity demand generated by the drive ramp function. The value is given in rpm if the vl_dimension_factor and the vl_setpoint_factor have the value 1, otherwise the value is in user units. Positive values indicate forward direction and negative values indicate reverse direction.

Table 7.38 vl_velocity_demand

0x6043	vl_velocity_demand			
Access: RO	**Range:** -32768 to +32767		**Size:** Signed 16	**Unit:** rpm
Default:	0			
Description:	Provides the instantaneous velocity demand generated by the drive ramp function			

7.5.3 0x6044 vl_velocity_actual_value

This read only object provides the velocity at the motor spindle or load. In a closed loop system this is determined from the motor feedback device and in an open loop system it is a copy of vl_velocity_demand.

The value is given in rpm if the vl_dimension_factor has the value of 1, otherwise the value is in user units. Positive values indicate forward direction and negative values indicate reverse direction.

Table 7.39 vl_velocity_actual_value

0x6044	vl_velocity_actual_value			
Access: RO	**Range:** -32768 to +32767		**Size:** Signed 16	**Unit:** N/A
Default:	0			
Description:	Provides the velocity at the motor spindle or load. Only available when in vl_velocity_mode.			

7.5.4 0x6046 vl_velocity_min_max_amount

This object is used to configure the minimum and maximum velocity.

The value is given in rpm if the vl_dimension_factor has the value of 1, otherwise the value is in user units.

Table 7.40 vl_velocity_min_max_amount

0x6046	vl_velocity_min_max_amount			
Sub-index 0				
Access: RO	**Range:** N/A		**Size:** Unsigned 8	**Unit:** N/A
Default:	2			
Description:	The number of last sub-indexes in this object.			
Sub-index 1				
Access: RW	**Range:** 0 to 0xFFFFFFFF		**Size:** Unsigned 32	**Unit:** rpm
Default:	0			
Description:	Used to configure the minimum velocity (both in the forward and reverse direction) that the system can operate at. Writing to this sub index will overwrite vl_velocity_min positive and vl_velocity_min negative.			
Sub-index 2				
Access: RW	**Range:** 0 to 0xFFFFFFFF		**Size:** Unsigned 32	**Unit:** rpm
Default:	2147483647			
Description:	Used to configure the maximum velocity (both in the forward and reverse direction) that the system can operate at. Writing to this sub index will overwrite vl_velocity_max positive and vl_velocity_max negative.			

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7.5.5 0x6047 vl_velocity_min_max

This object is used to configure the minimum and maximum velocity.

The value is given in rpm if the vl_dimension_factor has the value of 1, otherwise the value is in user units.

Table 7.41 0x6047 vl_velocity_min_max

0x6047	vl_velocity_min_max		
Sub-index 0			
Access: RO	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	4		
Description:	The number of last sub-indexes in this object.		
Sub-index 1			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	0		
Description:	Used to configure the minimum positive velocity at which the system can operate.		
Sub-index 2			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	2147483647		
Description:	Used to configure the maximum positive velocity at which the system can operate.		
Sub-index 3			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	0		
Description:	Used to configure the minimum negative velocity at which the system can operate.		
Sub-index 4			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	2147483647		
Description:	Used to configure the maximum negative velocity at which the system can operate.		

7.5.6 0x6048 vl_velocity_acceleration

This object is used to configure the delta speed and delta time of the slope of the acceleration ramp.

Example: To ramp to 1000 rpm in 5s, possible values for delta speed and delta time are 10000 and 50 respectively.

vl_velocity_acceleration = delta speed / delta time

Table 7.42 0x6048 vl_velocity_acceleration

0x6048	vl_velocity_acceleration		
Sub-index 0			
Access: RO	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2		
Description:	The number of last sub-indexes in this object.		
Sub-index 1			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	1000		
Description:	The value of delta speed is given in rpm if the vl_dimension_factor and the vl_setpoint_factor have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	**Range:** 0 to 65535	**Size:** Unsigned 16	**Unit:** s
Default:	2		
Description:	The value of delta time is given in seconds.		

7.5.7 0x6049 vl_velocity_deceleration

This object is used to configure the delta speed and delta time of the slope of the deceleration ramp.

Example: To decelerate by 800 rpm in 10s, possible values for delta speed and delta time are 8000 and 100 respectively.

vl_velocity_deceleration = delta speed / delta time

Table 7.43 0x6049 vl_velocity_deceleration

0x6049	vl_velocity_deceleration		
Sub-index 0			
Access: C	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2		
Description:	The number of last sub-indexes in this object.		
Sub-index 1			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	1000		
Description:	The value of delta speed is given in rpm if the vl_dimension_factor and the vl_setpoint_factor have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	**Range:** 0 to 65535	**Size:** Unsigned 16	**Unit:** s
Default:	2		
Description:	The value of delta time is given in seconds.		

7.5.8 0x604A vl_velocity_quick_stop

This object is used to configure the delta speed and delta time of the slope of the deceleration ramp for quick stop.

Example: To decelerate by 800 rpm in 10s, possible values for delta speed and delta time are 8000 and 100 respectively.

vl velocity deceleration = delta speed / delta time

Table 7.44 0x604A vl_velocity_quick_stop

0x604A	vl_velocity_quick_stop		
Sub-index 0			
Access: C	**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2		
Description:	The number of last sub-indexes in this object.		
Sub-index 1			
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** rpm
Default:	1000		
Description:	The value of delta speed is given in rpm if the vl_dimension_factor and the vl_setpoint_factor have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	**Range:** 0 to 65535	**Size:** Unsigned 16	**Unit:** s
Default:	2		
Description:	The value of delta time is given in seconds.		

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7.5.9 0x604B vl_setpoint_factor

This object is used to configure the numerator and denominator of the vl_setpoint_factor. The vl_setpoint_factor modifies the resolution or directing range of the specified setpoint. It does not influence the velocity limit function and the ramp function. A value of 0 must not be used.

Table 7.45 0x604B vl_setpoint_factor

0x604B	vl_setpoint_factor			
Sub-index 0				
Access: C		**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2			
Description:	The number of last sub-indexes in this object.			
Sub-index 1				
Access: RW		**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** N/A
Default:	1			
Description:	vl_setpoint_factor numerator (a value of 0 is not valid)			
Sub-index 2				
Access: RW		**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** N/A
Default:	1			
Description:	vl_setpoint_factor denominator (a value of 0 is not valid)			

7.5.10 0x604C vl_dimension_factor

This object is used to configure the numerator and denominator of the vl_dimension_factor. The vl_dimension_factor is used to scale the user units so that they can be used in a way that relates to the specific application.

Calculating the vl dimension factor:

Every user-specific velocity consists of a specific unit referred to as a specific unit of time (e.g. 1/s, bottles/min, m/s,...). The purpose of the vl_dimension_factor is to convert this specific unit to the revolutions/minute unit. A value of 0 must not be used.

Velocity [user-defined unit] / Dimension factor [rpm/user-defined unit] = Velocity [rpm]

Table 7.46 0x604C vl_dimension_factor

0x604C	vl_dimension_factor			
Sub-index 0				
Access: C		**Range:** N/A	**Size:** Unsigned 8	**Unit:** N/A
Default:	2			
Description:	The number of last sub-indexes in this object.			
Sub-index 1				
Access: RW		**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** N/A
Default:	1			
Description:	vl_dimension_factor numerator (a value of 0 is not valid)			
Sub-index 2				
Access: RW		**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** N/A
Default:	1			
Description:	vl_dimension_factor denominator (a value of 0 is not valid)			

The *vl_target_velocity* object is re-read every new profile cycle. It is scaled to appropriate units using the *vl_dimension_factor* and *vl_setpoint_factor* objects and then written to the drive preset reference 1 parameter (Pr **1.21**).

The object *vl_velocity_min_max* is handled every profile cycle. The *vl_target_velocity* is limited according to the values set in the object *vl_velocity_min_max*, which is read every profile cycle. The object *vl_velocity_min_max_amount* is mapped to *vl_velocity_min_max*.

The value of the *vl_velocity_demand* object is calculated in the background. The option reads the value of parameter Pr **2.01** (post ramp reference), scaled from RPM to user units using *vl_dimension_factor* and *vl_setpoint_factor*, and writes the value to the *vl_velocity_demand* object.

On a closed-loop drive, the speed feedback is read from the drive internally every profile cycle, scaled to the same units as *vl_target_velocity* and written to the *vl_velocity_actual_value* object. On an open-loop drive, the estimated motor speed is read from Pr **5.04** (motor RPM) in the background, scaled to the units of *vl_target_velocity* and written to the *vl_velocity_actual_value* object.

The *vl_velocity_acceleration* and *vl_velocity_deceleration* objects are handled in the background. They are read, scaled to drive acceleration units (depending on the drive operating mode), and written to the drive acceleration rate and deceleration rate presets. In addition, if the drive acceleration rate preset is changed, the *vl_velocity_acceleration* object is updated, and if the drive deceleration rate preset is changed (Pr **2.21**), the *vl_velocity_deceleration* object is updated.

7.6   Profile Torque mode

The profile torque mode is supported on Unidrive SP, Digitax ST, Affinity, Mentor MP and Commander SK. It is possible to use this profile in regen mode on the Unidrive SP. On the Unidrive SP and Digitax ST in closed-loop or servo mode, this mode operates on the profile cycle time, using the drives internal torque shortcut (which is read by the drive every 250µs). On the Commander SK, Unidrive SP and Affinity in open-loop mode, the torque reference is written to the drive user torque parameter, which is handled every 4ms. When using profile torque mode object 0x604A vl_velocity_quick_stop will be used in the event of a quick stop (also for quick stop option codes 2 and 6 the 0x6049 vl_velocity_deceleration object will be used).

Table 7.47 shows the objects that are supported:

Table 7.47 Profile torque mode supported objects

Index	Name
0x6071	*Target_torque*
0x6075	*Motor_rated_current*
0x6078	*Current_actual_value*
0x6087	*Torque_slope*

7.6.1 0x6071 Target_torque

This object indicates the configured input value for the torque controller in profile torque mode. The value of this object is given per thousand of rated torque.

Table 7.48 0x6071 Target_torque

0x6071	Target_torque		
Access: RW	**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** 0.1% of rated torque
Default:	0		
Description:	Indicates the configured input value for the torque controller in profile torque mode.		

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7.6.2 0x6075 Motor_rated_current

This object indicates the configured motor rated current. It is taken from the motor's name-plate. Depending on the motor and drive technology this current is DC, peak or rms (root-mean-square) current. All relative current data refers to this value. The value of this object is given in mA.

Table 7.49 0x6075 Motor_rated_current

0x6075	Motor_rated_current		
Access: RO	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** mA
Default:	0		
Description:	Indicates the configured motor rated current (Pr **5.07**).		

7.6.3 0x6078 Current_actual_value

This object provides the actual value of the current. It shall correspond to the current in the motor. The value of this object is given per thousand of rated current.

Table 7.50 0x6078 Current_actual_value

0x6078	Current_actual_value		
Access: RO	**Range:** -32768 to +32767	**Size:** Signed 16	**Unit:** 0.1% of rated current
Default:	0		
Description:	Provides the actual value of the current.		

7.6.4 0x6087 Torque_slope

This object indicates the configured rate of change of torque. The value of this object is given in units of per thousand of rated torque per second.

Table 7.51 Torque_slope

0x6087	Torque_slope		
Access: RW	**Range:** 0 to 0xFFFFFFFF	**Size:** Unsigned 32	**Unit:** 0.1% of rated torque per second
Default:	0		
Description:	Indicates the configured rate of change of torque.		

7.7 Homing Mode

This section describes the method by which a drive seeks the home position (also called, the datum, reference point or zero point).

Figure 7-2 *Homing mode function* on page 47 shows the defined input objects as well as the output objects. The user may specify the speeds, acceleration and the method of homing. There is a further object home offset, which allows the user to displace zero in the user's coordinate system from the home position.

There is no output data except for those bits in the statusword, which return the status or result of the homing process and the demand to the position control loops.

Figure 7-2 Homing mode function
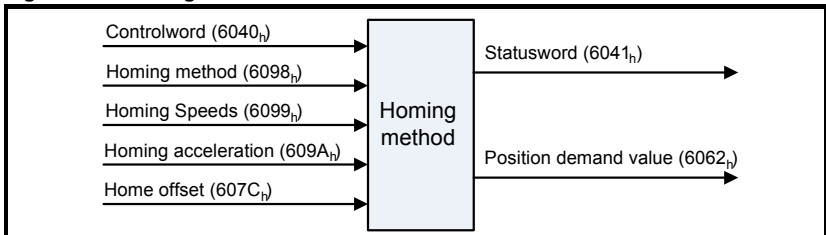
By choosing a homing method the following behaviour is determined: The homing signal (positive limit switch, negative limit switch, home switch), the direction of actuation and where appropriate the position of the index pulse.

An encircled number in Figure 7-3 to Figure 7-10 indicates the code for selection of this homing position. The direction of movement is also indicated.

There are four sources of homing signal available: These are the negative and positive limit switches, the home switch and the index pulse from an encoder.

In the diagrams of homing sequences shown below, the encoder count increases as the axis's position moves to the right, in other words the left is the minimum position and the right is the maximum position.

7.7.1 General homing definitions

Method 1: Homing on negative limit switch and index pulse

Using this method as shown in Figure 7-3 *Homing on negative limit switch and index pulse* on page 48, the initial direction of movement shall be leftward if the negative limit switch is inactive (here: low). The home position shall be at the first index pulse to the right of the position where the negative limit switch becomes inactive.

Figure 7-3 Homing on negative limit switch and index pulse
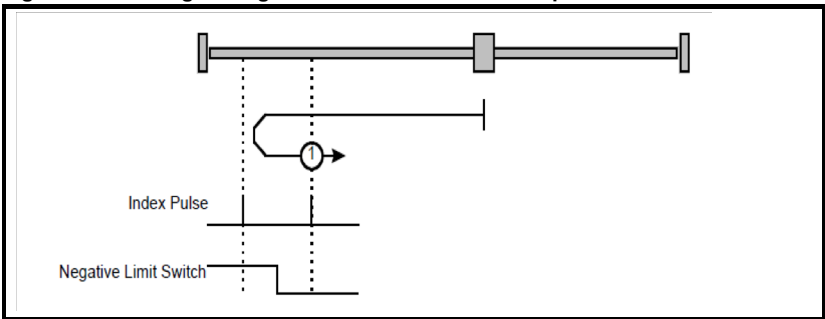
Method 2: Homing on positive limit switch and index pulse

Using this method as shown in Figure 7-4 *Homing on positive limit switch and index pulse* on page 48, the initial direction of movement shall be rightward if the positive limit switch is inactive (here: low). The position of home shall be at the first index pulse to the left of the position where the positive limit switch becomes inactive.
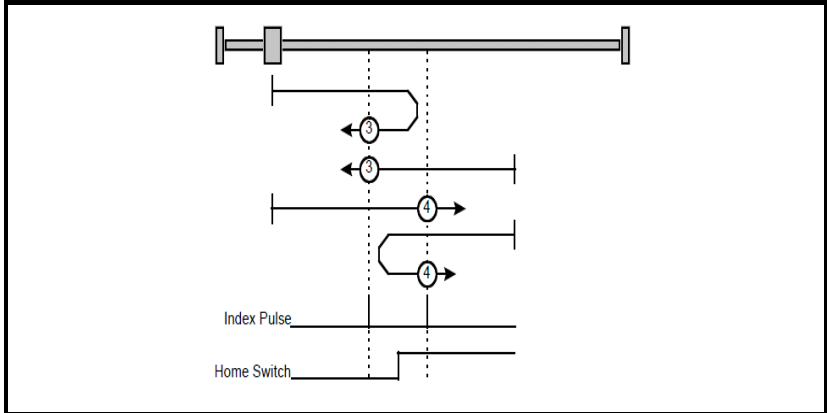
Figure 7-4 Homing on positive limit switch and index pulse
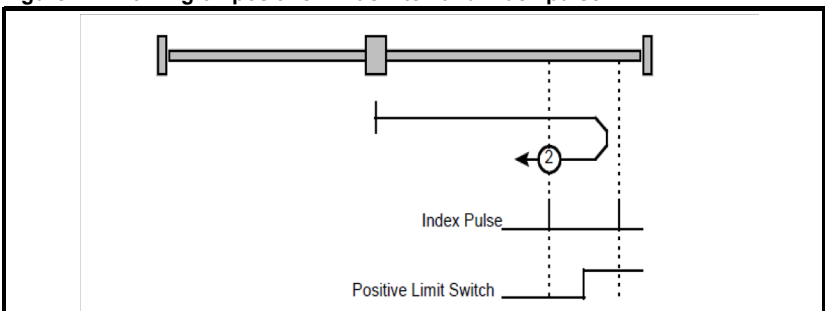
Method 3 and 4: Homing on positive home switch and index pulse

Using these methods as shown in Figure 7-5 *Homing on positive home switch and index pulse* on page 49, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be at the index pulse either to the left or the right of the point where the home switch changes state. If the initial position is sited so that the direction of movement shall reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

Figure 7-5 Homing on positive home switch and index pulse

Method 5 and 6: Homing on negative home switch and index pulse

Using these methods as shown in Figure 7-6 *Homing on negative home switch and index pulse* on page 49, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be at the index pulse either to the left or the right of the point where the home switch changes state. If the initial position is sited so that the direction of movement shall reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

Figure 7-6 Homing on negative home switch and index pulse
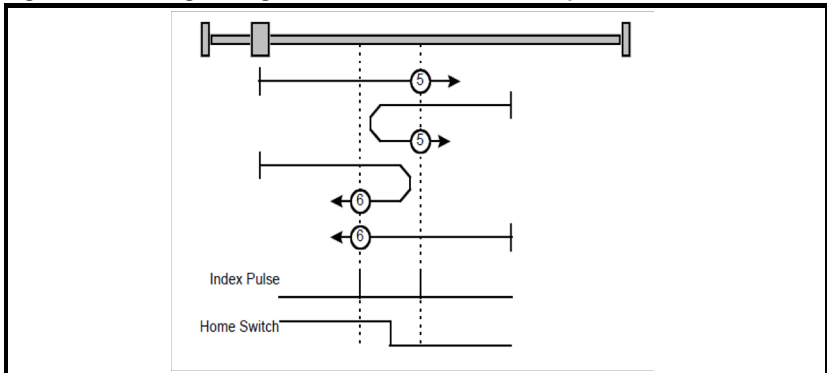
Method 7 to 14: Homing on home switch and index pulse

These methods use a home switch, which is active over only a portion of the travel; in effect the switch has a 'momentary' action as the axis's position sweeps past the switch. Using the methods 7 to 10, the initial direction of movement shall be to the right, and

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using methods 11 to 14 the initial direction of movement shall be to the left except if the home switch is active at the start of the motion. In this case the initial direction of motion shall be dependent on the edge being sought. The home position shall be at the index pulse on either side of the rising or falling edges of the home switch, as shown in Figure 7-7 *Homing on home switch and index pulse - positive initial motion* on page 50 and Figure 7-8 *Homing on home switch and index pulse - negative initial motion* on page 50. If the initial direction of movement leads away from the home switch, the drive shall reverse on encountering the relevant limit switch.

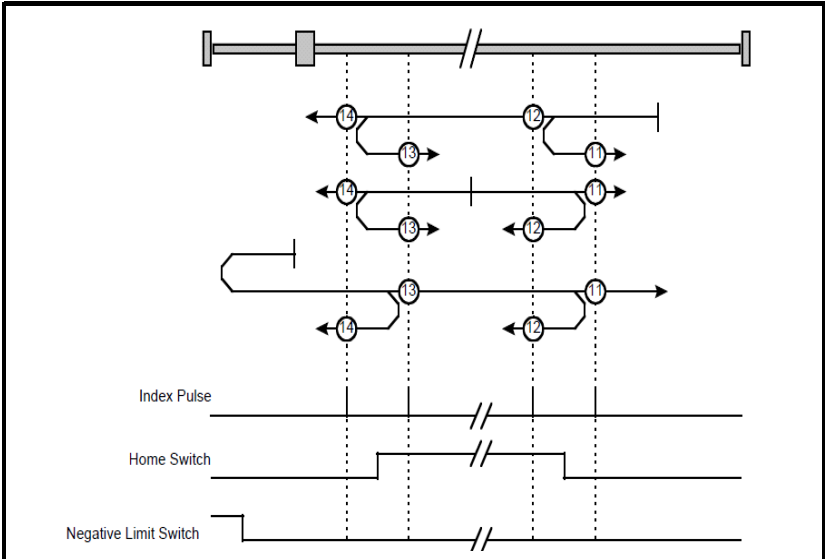**Figure 7-7 Homing on home switch and index pulse - positive initial motion**
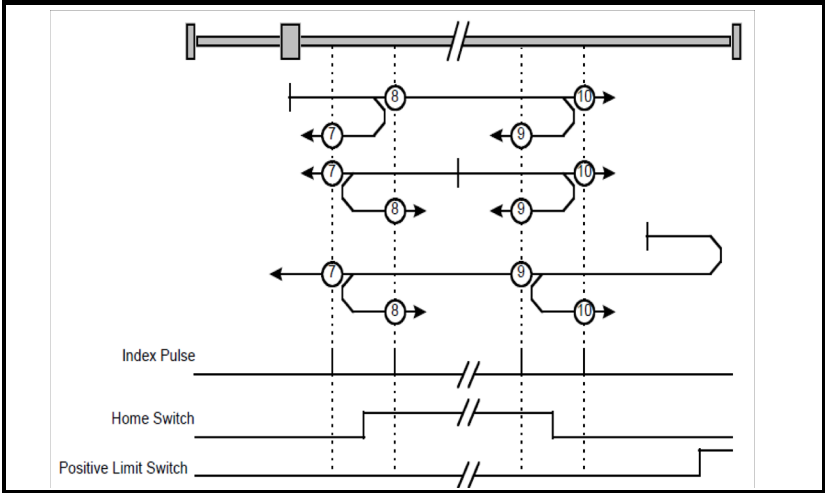
Figure 7-8 Homing on home switch and index pulse - negative initial motion

Method 15 and 16: Reserved

These methods are reserved.

Method 17 to 30: Homing without index pulse

These methods are similar to methods 1 to 14 except that the home position is not dependent on the index pulse but only dependent on the relevant home or limit switch transitions. For example methods 19 and 20 are similar to methods 3 and 4 as shown in Figure 7-9 *Homing on positive home switch* on page 51.

Figure 7-9   Homing on positive home switch
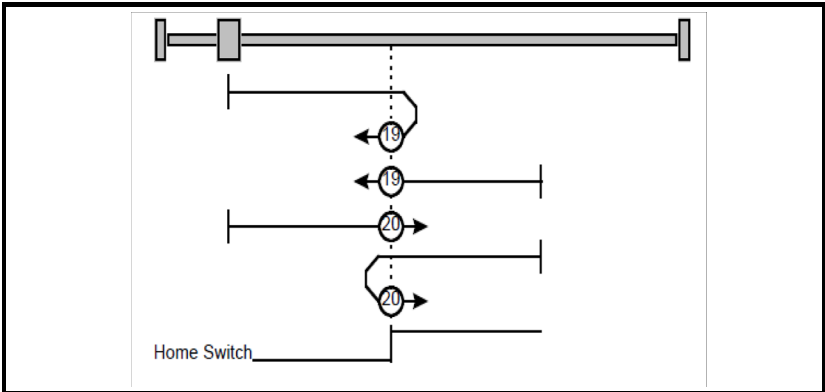
Method 31 and 32: Reserved

These methods are reserved.

Method 33 and 34: Homing on index pulse

Using these methods, the direction of homing is negative or positive respectively. The home position shall be at the index pulse found in the selected direction as shown in Figure 7-10 *Homing on index pulse* on page 51.

Figure 7-10   Homing on index pulse
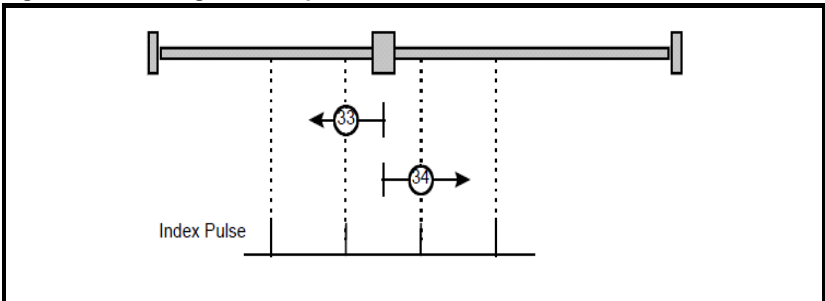
Method 35: Homing on index pulse

In this method, the current position shall be taken to be the home position. This method does not require the drive device to be in operational enabled state.

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Use of controlword and statusword

The homing mode uses some bits of the controlword and the statusword for mode-specific purposes. Table 7.52 *Definition of bits 4 and 8 of the controlword* on page 52 defines the values for bits 4 and 8 of the controlword.

Table 7.52 Definition of bits 4 and 8 of the controlword

Bit	Value	Definition
4	0	Do not start homing procedure.
	1	Start or continue homing procedure.
8	0	Enable bit 4.
	1	Stop axis according to halt option code (0x605D).

Table 7.53 *Definition of bits 10 and 12 of the statusword* on page 52 defines the values for bits 10 and 12 of the statusword.

Table 7.53 Definition of bits 10 and 12 of the statusword

Bit 12	Bit 10	Definition
0	0	Homing procedure is in progress.
0	1	Homing procedure is interrupted or not started.
1	0	Homing is attained, but target is not reached.
1	1	Homing procedure was completed successfully.
0	0	Homing error occurred, velocity is not 0.
0	1	Homing error occurred, velocity is 0.
1	X	Reserved.

7.7.2 Homing mode object definitions

0x2803 Homing source

This object indicates the configured source of the homing switch used during the homing procedure. Table 7.54 *Homing source* on page 52 specifies the object description.

Table 7.54 Homing source

0x2803	Homing source		
Sub-index 0			
Access: RO	Range: N/A	Size: Unigned 8	Unit: N/A
Default: 2			
Description: The number of the last sub-index in this object.			
Sub-index 1			
Access: RW	Range: 1 to 8	Size: Unsigned 8	Unit: N/A
Default: 5			
Description: The source of the homing switch. This will specify a digital input as follows: 1 to 6 - The number of a Drive digital input / 7 to 8 - SM-EtherCAT option module digital input 0 or 1			
Sub-index 2			
Access: RW	Range: 0 to 1	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: Use the feedback source freeze for homing. This will cause the freeze from the selected feedback device to be used instead of the index (marker) pulse when it is required during homing.			

0x2804 Freeze object

This object is used to configure the freeze function that can be used within the Homing mode profile. Table 7.55 *Freeze object* on page 53 specifies the object description.

Table 7.55 Freeze object

0x2804	Freeze object		
Sub-index 0			
Access: RO	Range: N/A	Size: Unigned 8	Unit: N/A
Default: 2			
Description: The number of the last sub-index in this object.			
Sub-index 1			
Access: RW	Range: 0 to 1	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: Route the option freeze onto the drive. Setting a value of 1 here will route the option digital input 0 onto the drive freeze line.			
Sub-index 2			
Access: RW	Range: 0 to 1	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: Option to drive freeze invert. Setting a value of 1 will invert the freeze signal routed onto the drive from the option input 0 (if 0x2804, sub-index 1 is set to 1). This value will be read only on a transition from 0 to 1 in sub-index 1.			

0x607C Home offset

This object indicates the configured difference between the zero position for the application and the machine home position (found during homing). During homing the machine home position is found and once the homing is completed the zero position is offset from the home position by adding the home offset to the home position. All subsequent absolute moves shall be taken relative to this new zero position. This is illustrated in Figure 7-11 *Home offset definition* on page 53. The value of this object shall be given in user-defined position units. Negative values indicate the opposite direction.
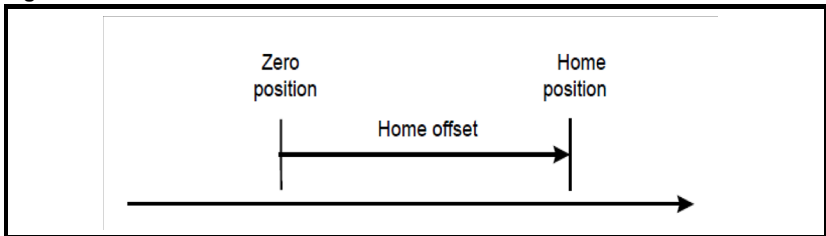
Figure 7-11 Home offset definition

Table 7.56 Home offset

0x607C	Home offset		
Access: RW	Range: -32768 to +32767	Size: Signed 32	Unit: User-defined position units
Default:	0		
Description:	Homing offset value.		

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0x6098 Homing method

This object indicates the configured homing method that shall be used. Table 7.57 *Homing method* on page 54 specifies the object description, and Table 7.58 *Homing method values* on page 54 specifies the value ranges for this object.

Table 7.57 Homing method

0x6098	Homing Method		
Access: RW	Range: 0 - 35	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: The homing method that shall be used.			

Table 7.58 Homing method values

Value	Definition
0	No homing method assigned
1	Method 1 shall be used
to	
34	Method 34 shall be used
35	Method 35 shall be used

0x6099 Homing speeds

This object indicates the configured speeds used during the homing procedure. The values shall be given in user-defined velocity units. Table 7.59 *Homing speeds* on page 54 specifies the object description.

Table 7.59 Homing speeds

0x6099	Homing speeds		
Sub-index 0			
Access: C	Range: 2	Size: Signed 8	Unit: N/A
Default: 2			
Description: The number of supported sub-indices.			
Sub-index 1			
Access: RW	Range: Unsigned 32	Size: Unsigned 32	Unit: N/A
Default: 0			
Description: Speed during search for a switch.			
Sub-index 2			
Access: RW	Range: Unsigned 32	Size: Unsigned 32	Unit: N/A
Default: 0			
Description: Speed during search for a zero.			

0x609A Homing acceleration

This object indicates the configured acceleration and deceleration to be used during the homing operation. The value shall be given in user-defined acceleration units. Table 7.60 *Homing acceleration* on page 54 specifies the object description.

Table 7.60 Homing acceleration

0x609A	Homing acceleration		
Access: RW	Range: Unsigned 32	Size: Unsigned 32	Unit: User-defined acceleration units
Default: 0			
Description:	Indicates the configured acceleration and deceleration to be used during homing operation.		

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8   Advanced features

8.1   Distributed clocks

SM-EtherCAT supports Distributed clocks. This is the scheme used by EtherCAT to accurately time synchronize slave devices. Position, speed and current control loops can all be synchronized.

When the option module is connected to a drive which can take a time synchronization signal (e.g. a Unidrive SP or Digitax ST), the EtherCAT distributed clocks facility can be used to provide this signal so the drive speed and current tasks are synchronized to the network. The position controller, and appropriate motion features will also be synchronized to the drive speed task.

NOTE   In CoE interpolated position mode the position command provided by the master every interpolation cycle time is used to generate a position command for the drive every 250μs.

8.2   SM-EtherCAT protocol support

The following are supported:

- Four Sync Managers. Two are used for the Mailbox Protocol (non-cyclic data) and two are used for process data (cyclic data)
- Distributed Clocks
- CANopen over EtherCAT (CoE)
- CMP protocol through Modbus RTU (only on the Unidrive SP, Digitax ST, Mentor MP and Affinity)

9 Diagnostics

9.1 Module identification parameters

The basic menu parameters can be accessed through the slot menu in the drive, Pr **MM.PP,** where **MM** is the menu for SM-EtherCAT in the host drive. The basic menu parameters may also be accessed using menu 60, i.e. Pr **60.PP**.

9.1.1 SM-EtherCAT module ID code

Table 9.1 SM-EtherCAT module ID code

SM-EtherCAT module ID code		
Pr **MM.01**	Default	421 (SM-EtherCAT)
	Range	-
	Access	RO

The module ID code indicates the type of module installed in the slot corresponding to menu **MM**. This is useful for checking the module is of the correct type.

9.1.2 SM-EtherCAT firmware version

Table 9.2 SM-EtherCAT firmware - major version

SM-EtherCAT firmware - major version (xx.yy)		
Pr **MM.02**	Default	N/A
	Range	00.00 to 99.99
	Access	RO

Table 9.3 SM-EtherCAT firmware - minor version

SM-EtherCAT firmware - minor version (zz)		
Pr **MM.51**	Default	N/A
	Range	0 to 99
	Access	RO

Unidrive SP/ Unidrive SPM/ Mentor MP

The software version of the Solutions Modules can be identified by looking at Pr **15.02** / Pr **16.02** or Pr **17.02** and Pr **15.51** / Pr **16.51** or Pr **17.51**.

Menu 15,16 or 17 is Solutions Module slot dependent with menu 17 being the lowest position nearest the control terminal connections.

The software version takes the form of xx.yy.zz, where Pr **15.02** displays xx.yy and Pr **15.51** displays zz (e.g. for software version 01.01.00 on a module in the middle Solutions Module slot, Pr **16.02** will display 1.01 and Pr **16.51** will display 0).

Digitax ST / Unidrive ES / Affinity

The software version of the Solutions Modules can be identified by looking at Pr **15.02** or Pr **16.02** and Pr **15.51** or Pr **16.51**.

Menu 15 or 16 is Solutions Module slot dependent with menu 15 being the position nearest the control terminal connections.

The software version takes the form of xx.yy.zz, where Pr **15.02** displays xx.yy and Pr **15.51** displays zz (e.g. for software version 01.01.00 on a module in the middle Solutions Module slot, Pr **16.02** will display 1.01 and Pr **16.51** will display 0).

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Commander SK / Commander SL

The software version of the Solutions Module can be identified by looking at Pr **15.02** and Pr **15.51**.

The software version takes the form of xx.yy.zz, where Pr **15.02** displays xx.yy and Pr **15.51** displays zz (e.g. for software version 01.01.00 Pr **15.02** will display 1.01 and Pr **15.51** will display 0).

9.2 Network configuration objects

9.2.1 SM-EtherCAT network loss trip

Table 9.4 Network loss behavior object

0x2813	Network loss behavior		
Sub-index 0:			
Access: RO	**Range:** N/A	**Size:** 1 byte	**Unit:** N/A
Default: 2			
Description: The number of last sub-indexes in this object.			
Sub-index 1: Maximum time interval			
Access: RW	**Range:** 0 to 65535	**Size:** 2 bytes	**Unit:** ms
Default: 0 (by default the network loss behavior is disabled)			
Description: The maximum time, in ms, allowed between accesses to PDOs (read or write). If no PDO access occurs for this period, the option will start network loss handling. If a value of zero is set, no network loss handling will occur.			
Sub-index 2: Trip type			
Access: RW	**Range:** 0 to 2	**Size:** 1 byte	**Unit:** N/A
Default: 0			
Description: Network loss trip type. If this value is set to 0, a network loss trip will never occur; however, a network loss will still be handled by stopping the drive and indicating a warning as previously described. If this value is set to 1, the network loss trip will occur only after the motor has been stopped according to the Fault reaction option code. If the value is set to 2, the network loss trip will occur immediately on network loss (this implies that the motor will coast).			

SM-EtherCAT resets an internal timer when a valid message is received from the EtherCAT network. The network loss trip is triggered when no new messages are received before the timer times out. The SM-EtherCAT will trip the drive and the SM-EtherCAT error code parameter (Pr **MM.50**) will show 120.

After power-up or reset the network loss trip is not armed until one of the following events occur:

• SYNC message is received.
• RxPDO is received

Once the trip has been armed, a minimum of one of the above messages must be received or transmitted in each time period set in sub-index 2 of the Network loss behavior object (0x2813).

9.3 Diagnostic parameters

Table 9.5 SM-EtherCAT operating status

SM-EtherCAT operating status		
Pr **MM.06**	**Default**	N/A
	Range	-9999 to 9999
	Access	RO

9.3.1 Running states

Table 9.6 Diagnostic information - running states

Pr **MM.06**	Meaning	Description
0	Link established	A link has been established but no frames are being transmitted or received.
> 0	Handled messages per second	The number of cyclic PDO messages that the active EtherCAT is handling per second.

Table 9.7 Diagnostic information - application

Pr **MM.06**	Meaning	Description
-99	Application started	The main application has been launched.
-70	Initialising file system	The file system is initialising.
-50	Initialising databases	The databases are initialising.
-30	Initialising fieldbus	The fieldbus is initialising.
-25	Starting fieldbus	The fieldbus is starting.
-1	Initialisation complete	The option module has initialised correctly but no network communication is taking place. i.e. no EtherCAT frames have been transmitted or received.

Table 9.8 Diagnostic information - bootloader

Pr **MM.06**	Meaning	Description
-199	Boot loader start	The bootloader is starting up.
-180	Initialising memory	The memory manager is being initialised.
-150	Initialising file system	The file system handler is being initialised.
-149	Format file system	The file system is being formatted.
-148	Verify file system	The file system is being verified.
-130	Check boot mode	The required boot mode is being checked.
-110	Loading application	The requested application image is being copied from the file system to memory.
-101	Launching application	The application is being launched.
-100	Default mode	The bootloader has finished but no application was launched.

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9.4   Drive trip display codes

If the SM-EtherCAT detects an error during operation, it will force a trip on the drive. However, the trip code displayed on the drive will only indicate which slot initiated the trip. The exact reason for the trip will be indicated in the SM-EtherCAT error code parameter, Pr **MM.50**.

Table 9.9 shows the possible trip codes that will be displayed on the drive when a problem is detected with SM-EtherCAT or when SM-EtherCAT initiates a trip.

Table 9.9 Drive trip display codes

Trip Code	Fault	Description
SLX.HF/ SL.HF	Hardware fault	The drive has detected that a Solutions Module is present, but is unable to communicate with it. If this occurs, please contact your supplier or local Control Techniques Drive Centre.
SLX.Er/ SL.Er	Error	Error trip generated by SM-EtherCAT
SLX.nF/ SL.nF	Not fitted	This trip will occur if a drive slot is configured for an option module, but no module is fitted in the slot.
SLX.dF/ SL.dF	Different module fitted	The slot configuration parameters stored in the drive are not valid SM-EtherCAT configuration parameters. This trip will also occur when an SM-EtherCAT is fitted to a previously un-used slot.

9.5   SM-EtherCAT module temperature

Table 9.10 SM-EtherCAT module temperature

SM-EtherCAT module temperature		
Pr **MM.44**	Default	N/A
	Range	0 - 255
	Access	RO

This parameter shows the option module temperature reading in degrees celcius.

9.6   SM-EtherCAT serial number

Table 9.11 SM-EtherCAT serial number

SM-EtherCAT serial number		
Pr **MM.35**	Default	N/A
	Range	0 - 16777215
	Access	RO

The serial number is loaded into the SM-EtherCAT during manufacture and cannot be changed. It contains the last eight digits of the 10-digit serial number of the label.

9.7 SM-EtherCAT error codes

Table 9.12 SM-EtherCAT error codes

SM-EtherCAT error codes		
Pr **MM.50**	Default	N/A
	Range	0 to 255
	Access	RO

If an error is detected during operation the module will force a trip on the drive and update the error code parameter (Pr **MM.50**). Table 9.13 shows the SM-EtherCAT error codes.

Table 9.13 SM-EtherCAT error codes

Error code	Fault
1	No fieldbus mode has been selected.
2	Critical task over-run.
3	Invalid feedback source
4	Unknown drive type
5	Unsupported drive type
10	Invalid or missing application
62	Database initialisation error.
63	File system initialisation error.
64	Error initialising fieldbus stack.
74	The option module has overheated.
75	The drive is not responding.
76	The Modbus connection has timed out.
80	Inter-option communication failure.
81	Inter-option communication to slot 1 timeout.
82	Inter-option communication to slot 2 timeout.
83	Inter-option communication to slot 3 timeout.
84	Memory allocation error.
85	File system error.
86	Configuration file error.
98	The option module background task has not been completed.
99	Software fault.

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9.8   Critical task % free

Table 9.14 SM-EtherCAT critical task % free

SM-EtherCAT critical task % free		
Pr **MM.46**	Default	N/A
	Range	0 to 100
	Access	RO

9.9   Worst case critical task % free

Table 9.15 Worst case critical task % free

SM-EtherCAT worst case critical task % free		
Pr **MM.47**	Default	N/A
	Range	0 to 100
	Access	RO

Parameters Pr **MM.46** and Pr **MM.47** indicate how much of the cycle time allocated to the critical task is remaining and available for other module tasks.

9.10   FLASH file system % free

Table 9.16 SM-EtherCAT FLASH file system % free

SM-EtherCAT FLASH file system % free		
Pr **MM.48**	Default	N/A
	Range	0 to 100
	Access	RO

Indicates what percentage of the flash based file system is unused and still available.

9.11   Updating SM-EtherCAT firmware

The SM-EtherCAT firmware is available from your local Control Techniques Drive Centre or supplier and can also be downloaded from CTSupport.com. To upload firmware to the SM-EtherCAT module the use of Winflasher is required, this application is also available from your local Control Techniques Drive Centre or supplier.

NOTE   It is important that the filename of the SM-EtherCAT firmware application file is not altered, doing so may result in problems with the firmware upload process.

NOTE   It is strongly recommended that the latest firmware be used where possible to ensure that all features are supported.

NOTE   The minimum Winflasher firmware version with SM-EtherCAT support is V03.07.00.

10 Quick Reference

Table 10.1 and Table 10.2 list of all the SM-EtherCAT set-up objects and parameters that are required to configure the module.

Table 10.1 SM-EtherCAT objects reference

Object	Name	Description	Cross reference
0x1000	Device type	Specifies the device profile being used (DSP-402).	Section 6.1.1 on page 20
0x1018	Identity object	Contains SM-EtherCAT specific identity information.	Section 6.1.1 on page 20
0x1600	Receive PDO mapping 1	Contains the mapping information for receive PDO mapping 1.	Section 6.1.2 on page 21
0x1601	Receive PDO mapping 2	Contains the mapping information for receive PDO mapping 2.	Section 6.1.2 on page 21
0x1605	Receive PDO mapping 6	Contains the mapping information for receive PDO mapping 6.	Section 6.1.2 on page 21
0x1621	Receive PDO mapping 22	Contains the mapping information for receive PDO mapping 22.	Section 6.1.2 on page 21
0x1A00	Transmit PDO mapping 1	Contains the mapping information for transmit PDO mapping 1.	Section 6.1.3 on page 23
0x1A01	Transmit PDO mapping 2	Contains the mapping information for transmit PDO mapping 2.	Section 6.1.3 on page 23
0x1A02	Transmit PDO mapping 3	Contains the mapping information for transmit PDO mapping 3.	Section 6.1.3 on page 23
0x1A05	Transmit PDO mapping 6	Contains the mapping information for transmit PDO mapping 6.	Section 6.1.3 on page 23
0x1A21	Transmit PDO mapping 22	Contains the mapping information for transmit PDO mapping 22.	Section 6.1.3 on page 23
0x1C00	Sync manager communication type	This read-only object provides sync manager usage details.	Section 6.1.4 on page 26
0x1C10	Sync manager 0 PDO assignment	This read-only object contains information relating to the non-cyclic receive mailbox.	Section 6.1.4 on page 26
0x1C11	Sync manager 1 PDO assignment	This read-only object contains information relating to the non-cyclic send mailbox.	Section 6.1.4 on page 26
0x1C12	Sync manager 2 PDO assignment	Contains the currently in use receive PDOs.	Section 6.1.4 on page 26
0x1C13	Sync manager 3 PDO assignment	Contains the currently in use transmit PDOs.	Section 6.1.4 on page 26
0x2813	Network loss behavior object	Used to configure the network loss trip behavior (watchdog).	Section 9.2.1 on page 57
0x6040	Controlword	Provides the primary method of control-ling the behavior of the drive.	Section 7.1 on page 28
0x6041	Statusword	This provides feedback about the current operating state of the drive.	Section 7.2 on page 29
0x6042	vl_target_velocity	Used to set the required velocity of the system.	Section 7.5.1 on page 41
0x6043	vl_velocity demand	Provides the instantaneous velocity demand generated by the drive ramp function.	Section 7.5.2 on page 42

Table 10.1 SM-EtherCAT objects reference

Object	Name	Description	Cross reference
0x6044	vl_velocity_actual value	Provides the velocity at the motor spindle or load.	Section 7.5.3 on page 42
0x6046	vl_velocity_min max_amount	This object is used to configure the minimum and maximum velocity.	Section 7.5.4 on page 42
0x6047	vl_velocity_min max	This object is used to configure the minimum and maximum velocity.	Section 7.5.5 on page 43
0x6048	vl_velocity acceleration	This object is used to configure the delta speed and delta time of the slope of the acceleration ramp.	Section 7.5.6 on page 43
0x6049	vl_velocity deceleration	This object is used to configure the delta speed and delta time of the slope of the deceleration ramp.	Section 7.5.7 on page 44
0x604A	vl_velocity_quick stop	This object is used to configure the delta speed and delta time of the slope of the deceleration ramp for quick stop.	Section 7.5.8 on page 44
0x604B	vl_setpoint factor	This object is used to configure the numerator and denominator of the vl_setpoint_factor.	Section 7.5.9 on page 45
0x605A	Quick_stop option_code	Specifies what action is performed in the event of a quick stop function	Section 7.3.2 on page 33
0x605B	Shutdown_option code	Used to control what action is performed if there is a transition from the Operation Enabled state to the Ready To Switch On state.	Section 7.3.3 on page 34
0x605C	Disable operation_option code	This object is used to control what action is performed if there is a transition from the Operation Enabled state to the Switched On state.	Section 7.3.4 on page 34
0x605E	Fault_reaction option_code	This object is used to control what action is performed when a fault is detected.	Section 7.3.5 on page 34
0x6060	Modes_of operation	This object is used to request a change in the mode of operation.	Section 7.3.6 on page 35
0x6061	Modes of operation display	This read only object is used to provide the active mode of operation.	Section 7.3.7 on page 35
0x6062	Position_demand value	Used to provide the currently demanded position value.	Section 7.3.14 on page 38
0x6064	Position_actual value	This read only object provides the actual value of the position feedback device.	Section 7.3.15 on page 38
0x6085	Quick_stop deceleration	This object is used to configure the deceleration rate used to stop the motor when the quickstop function is activated and the quick stop code object (0x605A) is set to 2 or 6.	Section 7.3.8 on page 35
0x608F	Position_encoder resolution	This read only object indicates the configured encoder increments per number of motor revolutions.	Section 7.3.10 on page 36
0x6091	Gear_ratio	This object is used to apply scaling.	Section 7.3.11 on page 36
0x6092	Feed_constant	This is used to configure a feed constant.	Section 7.3.12 on page 37
0x60F4	Following_error actual_value	This read only object provides the actual value of the following error.	Section 7.3.16 on page 38
0x60FB	Position_control parameter_set object	Used to configure the positional control gains.	Section 7.3.17 on page 39

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Table 10.1 SM-EtherCAT objects reference

Object	Name	Description	Cross reference
0x60C0	Interpolation sub-mode_select	Specifies the interpolation type.	Section 7.4.1 on page 39
0x60C1	Interpolation data_record	This object is used to specify the target position.	Section 7.4.2 on page 40
0x60C2	Interpolation time_period	The number of time units between inter-polator re-starts.	Section 7.4.3 on page 40

Table 10.2 SM-EtherCAT parameter reference

Object	Description	Default	Range	Cross reference
Pr **MM.01**	SM-EtherCAT module ID code	421	---	Section 9.1.1 on page 56
Pr **MM.02**	SM-EtherCAT firmware - major version	N/A	00.00 to 99.99	Section 9.1.2 on page 56
Pr **MM.06**	SM-EtherCAT operating status	N/A	-9999 to 9999	Section 9.3 on page 58
Pr **MM.32**	SM-EtherCAT re-initialise	0 (OFF)	0 (OFF) to 1 (ON)	Section 5.4 on page 18
Pr **MM.35**	SM-EtherCAT serial number	N/A	0 - 16777215	Section 9.6 on page 59
Pr **MM.44**	SM-EtherCAT module temperature	N/A	0 - 255	Section 9.5 on page 59
Pr **MM.46**	Critical task % free	N/A	0 to 100	Section 9.8 on page 61
Pr **MM.47**	Worst case criti-cal task % free	N/A	0 to 100	Section 9.9 on page 61
Pr **MM.48**	Flash file system % free	N/A	0 to 100	Section 9.10 on page 61
Pr **MM.50**	SM-EtherCAT error code	N/A	0 to 255	Section 9.7 on page 60
Pr **MM.51**	SM-EtherCAT firmware - minor version	N/A	0 to 99	Section 9.1.2 on page 56

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Address: This is the unique network identification given to a networked device to allow communication on a network. When a device sends or receives data the address is used to determine the source and the destination of the message.

Bit: A binary digit, this may have the value of 1 or 0.

Byte: A collection of eight binary digits that collectively store a value. This may be signed or unsigned.

Control word: A collection of binary digits that are used to control the drive. Features typically include directional controls, run controls and other similar functions.

Cyclic: Data that is transmitted at regular intervals over the network.

Data rate: Determines the communication speed of the network, the higher the value the more data can be sent across the network in the same time period.

Device: A piece of equipment connected to a network, this may be any type of equipment including repeaters, hubs, masters or slaves.

Double word: A 32-bit word, this may be signed or unsigned.

Earthing / Grounding: Describes the electrical safety or shielding connections for the module.

LED: Light emmiting diode.

Long word: A 32-bit data word that may be signed or unsigned.

LSB: Least significant bit/byte.

MSB: Most significant bit/byte.

Node: A device on the network. This may be either a device such as a drive or part of the network such as a repeater.

Non-cyclic data: Data that is requested or sent as required and not on a regular basis.

Octet: A collection of eight binary digits which form a byte.

PC: Personal computer.

PLC: Programmable logic controller.

Poll rate: The rate at which cyclic data is sent and received on the network.

Polled data: *See Cyclic data*.

Scan rate: See *Poll rate*.

Screening: A connection to provide additional immunity to noise used on a network cable.

Shielding: A connection to provide additional immunity to noise used on a network cable.

Status word: A value that denotes the status of the drive. Each bit within the word will have a specific meaning.

Word: A collection of sixteen binary digits.

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0471-0128-02